PROPOSED ORGANIC ENRICHMENT/LOW DISSOLVED OXYGEN

TOTAL MAXIMUM DAILY LOAD (TMDL) FOR WATERS IN THE

HARPETH RIVER WATERSHED (HUC 05130204)

September 30, 2003

Region 4 serving the southeast

Executive Summary

The Tennessee Department of Environment and Conservation (TDEC) included several waters in the Harpeth River Basin on its 1998 §303(d) list of impaired waters for the pollutant cause, "organic enrichment/DO," including the segments identified in the Table below. The TMDLs proposed in this report will address the organic enrichment/DO impairment for all the segments included in this table.

Water Quality Limited Segments Addressed by this TMDL from TDEC's 1998 303(d) List

Impacted Waterbody	CAUSE (Pollutant)	Pollutant Source	Length of Impairment
HARPETH RIVER From W Fk Harpeth to headwaters is partially supporting	Org. enrichment/DO Siltation Habitat alteration Metals (As, Pb, Zn, Sb)	Agriculture Contaminated sediment Urb. Runoff/storm sewers Major Mun. Point Source Industrial Point Source	37.3 miles
HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr	Org. enrichment/DO Siltation Habitat alteration	Agriculture Riparian loss	79.0 miles
HARPETH RIVER TRIBUTARIES Concord Cr, Puckett, Cheatham, Kelley, portion of Harpeth headwaters	Org. enrichment/DO Siltation Habitat alteration	Agriculture Riparian loss	35.7 miles
HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting	Org. enrichment/DO Siltation Habitat alteration	Patureland Urb. Runoff/ storm sewers Riparian loss	10.4 miles
HARPETH RIVER TRIBUTARIES Beech and unn. Trib to Harpeth are not supporting	Org. enrichment/DO Siltation Habitat alteration	Riparian loss Urb. Runoff/ Storm sewers	5.7 miles
WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting	Org. enrichment/DO Siltation Habitat alteration	Riparian loss Pastureland	62.1 miles
W. FORK HARPETH TRIBUTARIES Rattlesnake Branch is not supporting	Org. enrichment/DO Siltation Habitat alteration	Agriculture	6.5 miles

On TDEC's 2002 §303(d) list, additional segments in the Harpeth River watershed are identified as impaired from the pollutant causes "organic enrichment/Low DO" and "Low DO." The TMDLs proposed in this report will also address all the segments included in Table 2 for the identified pollutant causes.

Water Quality Limited Segments Addressed by this TMDL from TDEC's 2002 303(d) List

Waterbody ID	Impacted Waterbody	CAUSE (Pollutant)	Pollutant Source	Length of Impairment
TN05130204009-2000	HARPETH RIVER From South Harpeth River to the Little Harpeth River	Organic Enrichment/Low DO	Major Municipal Point Source Minor Municipal Point Source Urban Runoff/Storm Sewers	18.8 miles
TN05130204009-3000	HARPETH RIVER From Little Harpeth River to the West Harpeth River	Organic Enrichment/Low DO	Major Municipal Point Source Minor Municipal Point Source Urban Runoff/Storm Sewers	16.8 miles
TN05130204021-1000	LITTLE HARPETH RIVER From Harpeth River to Otter Cr	Low DO	Land Development	4.1 miles

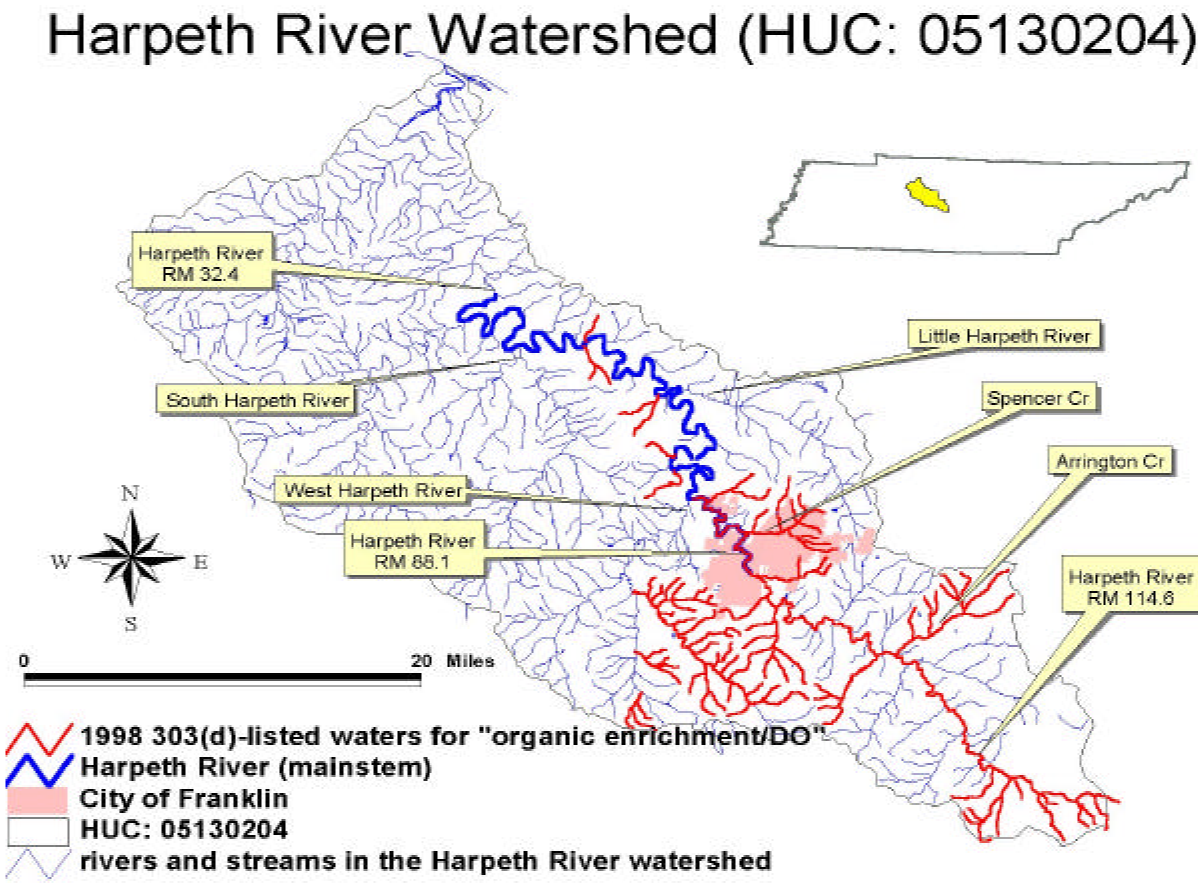

Illustration of the Impaired Waterbodies in the Harpeth River Watershed.

The TMDL report is comprised of three components. They are: 1) watershed nutrient load reduction evaluation to address the water quality impacts in the tributaries; 2) an assessment of dissolved oxygen impacts of the upper mainstem of the Harpeth River; and 3) an assessment of dissolved oxygen impacts of the lower Harpeth River from river mile 88.1 to river mile 32.4. These components contain source assessments, documentation of existing conditions, and an evaluation of the pollutant load reductions necessary to attain water quality standards. The allowable pollutant loads for each component of this TMDL report are summarized in the tables presented below.

Nutrient Reduction TMDL to Protect the Tributaries to the Harpeth River

The allowable nutrient loads for these impaired subwatersheds of the Harpeth River were calculated by TDEC using an interpretation of their narrative nutrient criteria for biological integrity. TDEC calculated eco-region based criteria for total nitrogen and total phosphorous and applied these concentrations to the average monthly flows of the tributaries to estimate the allowable pounds per month which would meet the nutrient criteria. In addition, the dissolved oxygen impairments should be resolved by reducing the periphyton and algal growth that produce diurnal variations in dissolved oxygen.

Nutrient TMDLs for Selected Impaired Subwatersheds

HUC-12 Subwatershed (05130204)	Total Nitrogen		Total Phosphorus	
	Summer * [lbs/month]	Winter * [lbs/month]	Summer * [lbs/month]	Winter * [lbs/month]
0101	4480	12478	916	2541
0104	7335	21966	929	2709
0105	5864	18260	483	1505
0201	4062	12649	335	1042
0202	3026	9119	241	732
0301	6253	18537	489	1468
0302	5275	16425	435	1354

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

Estimates of Required Load Reductions for Selected Impaired Subwatersheds

HUC-12 Subwatershed (05130204)	Total Nitrogen (%)	Total Phosphorus (%)
0101	20.0	42.4
0104	20.0	42.4
0105	49.4	83.8
0201	53.1	81.3
0202	53.1	81.3
0301	44.8	82.4
0302	34.3	78.1

The Upper Harpeth River Pollutant Load Reductions

Due to the highly variable and extreme low flow conditions experienced in the upper Harpeth River, a steady state water quality model, QUAL2E, was used to evaluate pollution reduction scenarios for this portion of the Harpeth River. In this portion of the River, the principal cause for the dissolved oxygen deficit is the presence of excessive sediment oxygen demanding material. A 65% reduction of this material is necessary to achieve the 5.0 mg/l dissolved oxygen criterion. The nonpoint agricultural and urban runoff sources are targeted for pollutant load reductions. It was determined that the small NPDES dischargers in the upper Harpeth River watersheds can operate at design capacity if the sediment oxygen demanding waste emanating from the storm water runoff is reduced by 65%. This pollutant load reduction is more stringent on an annual average basis than the nutrient load reductions designed to meet water quality standards in the tributaries alone.

Wasteload Allocation to protect DO levels in the headwaters of the Harpeth River

NPDES facility	Summer Total Nitrogen Load (lbs/month)	Winter Total Nitrogen Load (lbs/month)	* Summer Total Phosphorus Load (lbs/month)	* Winter Total Phosphorus Load[a] (lbs/month)	** Total $CBOD_5$ Load a (lbs/month)
Eagleville School (TN0057789)	45.0	67.6	22.5	33.8	45.0
Page School (TN0057835)	20.0	69.0	24.0	36.0	20.0
Goose Creek Inn (TN0060216)	69.0	104.0	36.0	54.0	69.0
Oakview Elementary (TN0067873)	23.0	35.0	12.0	18.0	23.0
CAFOs	0	0	0	0	0
MS4s	NA	NA	NA	NA	NA

Notes: a – The allowable CBOD5 load is based on the facilities permitted limits

Load Allocation to protect DO levels in the headwaters of the Harpeth River

12-digit subwatershed	Total Nitrogen Load (lbs/year)	Total Phosphorus Load (lbs/year)	Total Reduction in CBOD (percent)
05130204 0101	35,700	7,350	65%

The Lower Harpeth River Pollutant Load Reductions

The lower Harpeth River from river mile 88.1 to river mile 34.2 is impaired due to low dissolved oxygen under low flow conditions. This portion of the River was modeled with a hydrodynamic model RIV1 and WASP6. This calibrated and verified model was used to assess existing conditions as well as predict impacts with NPDES facilities operating at design flow conditions. There is one major NPDES discharge, the City of Franklin WWTP, which will require a load reduction of 33% at design flow of 12 MGD to address a predicted dissolved oxygen deficit, 4.5 mg/l dissolved oxygen, ten miles downstream of the discharge. The model documents that the most severe dissolved oxygen deficit, 1.0 mg/l dissolved oxygen, under existing conditions occurs about 40 miles downstream of the Franklin discharge. The assessment of the dissolved oxygen deficit indicated that the sediment oxygen demand has to be reduced by 40% in order to attain the water quality criterion of 5.0 mg/l. Since this sediment oxygen demand load reduction is comparable to the required nutrient load reductions for the subwatersheds impacting the lower Harpeth River, EPA believes that these watershed pollutant controls along with future Franklin WWTP controls will be sufficient to enable the lower Harpeth River to attain water quality standards.

Wasteload Allocation to WWTPs to protect DO levels in the lower Harpeth River in Critical Summer Conditions

Facility	Design Flow MGD	CBOD5 lbs/day	Ammonia lbs/day	Total N lbs/day
Franklin	12.0	400 (4.0mg/l)	40 (0.4 mg/l)	290 (3.0 mg/l)
Lynnwood	0. 4	17 (5.0 mg/l)	7 (2.0mg/l)	22 (6.6 mg/l)
Cartwright	0.25	10 (5.0 mg/l)	4 (2.0 mg/l)	14 (7.0 mg/l)

Wasteload (MS4 area) and Load Allocations to Watershed Runoff protect DO levels in the lower Harpeth River in Critical Summer Conditions

HUC-12 Subwatershed (05130204)	Total Nitrogen Summer lbs/month	Total Nitrogen Winter lbs/month	WLA Percent Reduction in MS4 Area	LA Percent Reduction in rural area
0104	7335	12478	20.0	20.0
0105	5864	21966	49.4	49.4
0201	4062	12649	53.1	53.1
0202	3026	9119	53.1	53.1
0301	6253	18537	44.8	44.8
0302	5275	16425	34.3	34.3

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Introduction

Section 303(d) of the Clean Water Act (CWA) requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not attaining water quality standards. State water quality standards consist of designated use(s) for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources.

The Tennessee Department of Environment and Conservation (TDEC) included several waters in the Harpeth River Basin on its 1998 §303(d) list of impaired waters for the pollutant cause, "organic enrichment/DO," including the segments identified in Table 1 below. The TMDLs proposed in this report will address the organic enrichment/DO impairment for all the segments included in this table.

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WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting	Org. enrichment/DO Siltation Habitat alteration	Riparian loss Pastureland	62.1 miles
W. FORK HARPETH TRIBUTARIES Rattlesnake Branch is not supporting	Org. enrichment/DO Siltation, Habitat alteration	Agriculture	6.5 miles

In May 2001, the U.S. Environmental Protection Agency (EPA) entered into a Settlement Agreement with the Tennessee Environmental Council, the Foundation for Global Sustainability, the Lumsden Bend Community Group, the Tennessee Scenic Rivers Association, and the Tennessee Riverkeeper. Consistent with the provisions of the Settlement Agreement, EPA is proposing TMDLs to address the organic enrichment/DO impairment for the waters identified in Table 1.

As part of the process for developing TMDLs for the Harpeth River waters to address organic enrichment/DO, EPA has worked closely with TDEC during the past four years in water quality data collection efforts, water quality assessments, and the development of technical tools to develop TMDLs including water quality models. On July 31, 2002, EPA coordinated an effort with TDEC to complete a report entiltled, "Harpeth River Watershed Modeling Effort: A Tool for TMDL Development", which documented a system of four models representing physical, chemical, and biological processes in the Harpeth River watershed. Specifically, the models include: 1) an application of the watershed model, Loading Simulation Program in C++ (LSPC), to the Harpeth River watershed as defined by the hydrologic unit code (HUC) 05130204; 2) an application of the steady-state, one-dimensional dissolved oxygen model, QUAL2E, to the upper portion of the mainstem of the Harpeth River (i.e., upstream from River Mile 89.2); 3) an application of the one-dimensional, hydrodynamic model CE-QUAL-RIV1 to the lower portion of the mainstem of the Harpeth River (i.e., from River Mile 88.1 to 32.4); and 4) a linkage of the Water Quality Analysis Program (WASP) 6.0 eutrophication model with the CE-QUAL-RIV1 hydrodynamic model. A copy of this modeling report is concurrently being made available with the public notice of this Harpeth River watershed TMDL report on EPA's internet website at: www.epa.gov/region4/water/TMDL/.

On TDEC's 2002 §303(d) list, additional segments in the Harpeth River watershed are identified as impaired from the pollutant causes "organic enrichment/Low DO" and "Low DO." The TMDLs proposed in this report will also address all the segments included in Table 2 for the identified pollutant causes.

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Waterbody ID	Impacted Waterbody	CAUSE (Pollutant)	Pollutant Source	Length of Impairment
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TN05130204021-1000	LITTLE HARPETH RIVER From Harpeth River to Otter Cr	Low DO	Land Development	4.1 miles

EPA has not yet taken action on the submittal of TDEC's 2002 §303 list. Consistent with EPA's current policy regarding federal TMDL proposals for waters that are not currently on an approved State §303 list, EPA is soliciting data, information, and comments concerning the impairment status of the waters identified in Table 2. Although these waters are not currently on an approved §303 list, EPA and TDEC are in full agreement that these waters are impaired for the pollutant causes identified in Table 2. This conclusion was reached by EPA and TDEC based on an assessment of water quality data that was collected by EPA and TDEC from these waters between 2000 and 2002. Considering that these segments, and their water quality and physical properties, are interconnected (see

Figure 1), EPA and TDEC believe that it is important to propose and establish TMDLs for these segments concurrent with the TMDLs proposed for the 1998 §303-listed segments.

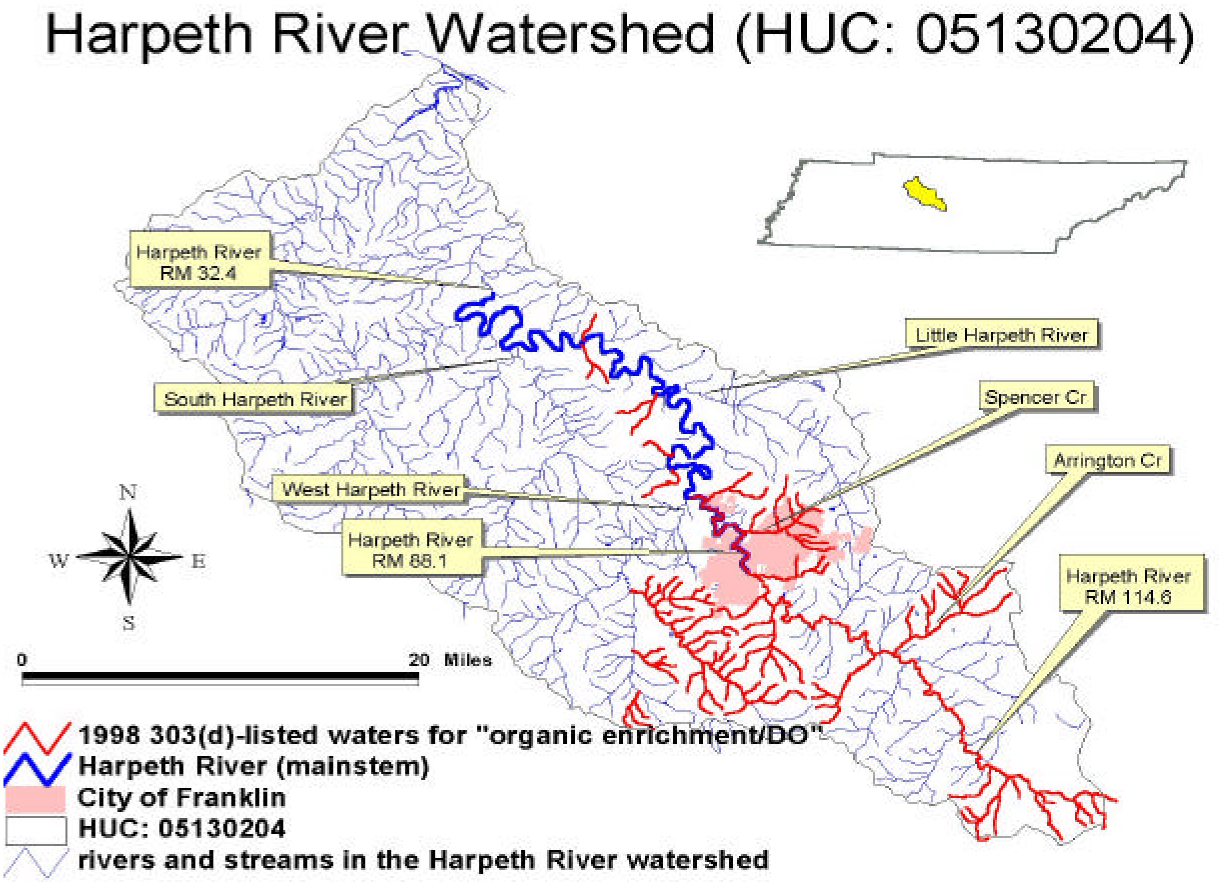

Figure 1 Harpeth River Watershed

General Watershed Overview

The Harpeth River watershed (HUC 05130204) is located in Middle Tennessee (Figure 1) and includes parts of Cheatham, Davidson, Dickson, Hickman, Rutherford, and Williamson Counties. The watershed lies within the Level III Interior Plateau (71) ecoregion and contains three Level IV ecoregions as shown in Figure 3 (USEPA, 1997):

- Western Highland Rim (71f) is characterized by dissected, rolling terrain of open hills, with elevations of 400 to 1000 feet. The geologic base of Mississippian-age limestone, chert, and shale is covered by soils that tend to be cherty, acidic and low to moderate in fertility. Streams are characterized by coarse chert gravel and sand substrates with areas of bedrock, moderate gradients, and relatively clear water. The oak-hickory natural vegetation was mostly deforested in the mid to late 1800's, in conjunction with the iron ore related mining and smelting of the mineral limonite, but now the region is again heavily forested. Some agriculture occurs on the flatter areas between streams and in the stream and river valleys: mostly hay, pasture, and cattle, with some cultivation of corn and tobacco.

- Outer Nashville Basin (71h) is a more heterogeneous region than the Inner Nashville Basin, with more rolling and hilly topography and slightly higher elevations. The region encompasses most all of the outer areas of the generally non-cherty Ordovician limestone bedrock. The higher hills and knobs are capped by the more cherty Mississippian-age formations, and some Devonian-age Chattanooga shale, remnants of the Highland Rim. The region's limestone rocks and soils are high in phosphorus, and commercial phosphate is mined. Deciduous forests with pasture and cropland are the dominant land covers. Streams are low to moderate gradient, with productive nutrient-rich waters, resulting in algae, rooted vegetation, and occasionally high densities of fish. The Nashville Basin as a whole has a distinctive fish fauna, notable for fish that avoid the region, as well as those that are present.

- Inner Nashville Basin (71i) is less hilly and lower than the Outer Nashville Basin. Outcrops of the Ordovician-age limestone are common, and the generally shallow soils are redder and lower in phosphorus than those of the Outer Basin. Streams are lower gradient than surrounding regions, often flowing over large expanses of limestone bedrock. The most characteristic hardwoods within the Inner Basin are a maple-oak-hickory-ash association. The limestone cedar glades of Tennessee, a unique mixed grassland/forest/cedar glades vegetation type with many endemic species, are located primarily on the limestone of the Inner Nashville Basin. The more xeric, open characteristics and shallow soils of the cedar glades also result in a distinct distribution of amphibian and reptile species.

The Harpeth River watershed has approximately 1,364 miles of streams (Rf3) and drains a total area of 867 square miles. The Harpeth River is approximately 125 miles in length and flows generally in a northwesterly direction before draining to River Mile (RM) 152.9 of the Cumberland River. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the Harpeth River watershed have occurred since 1993 as a result of rapid development, this is the most current land use data available. Land use for the Harpeth River watershed is summarized in Table 3 and shown in Figure 3.

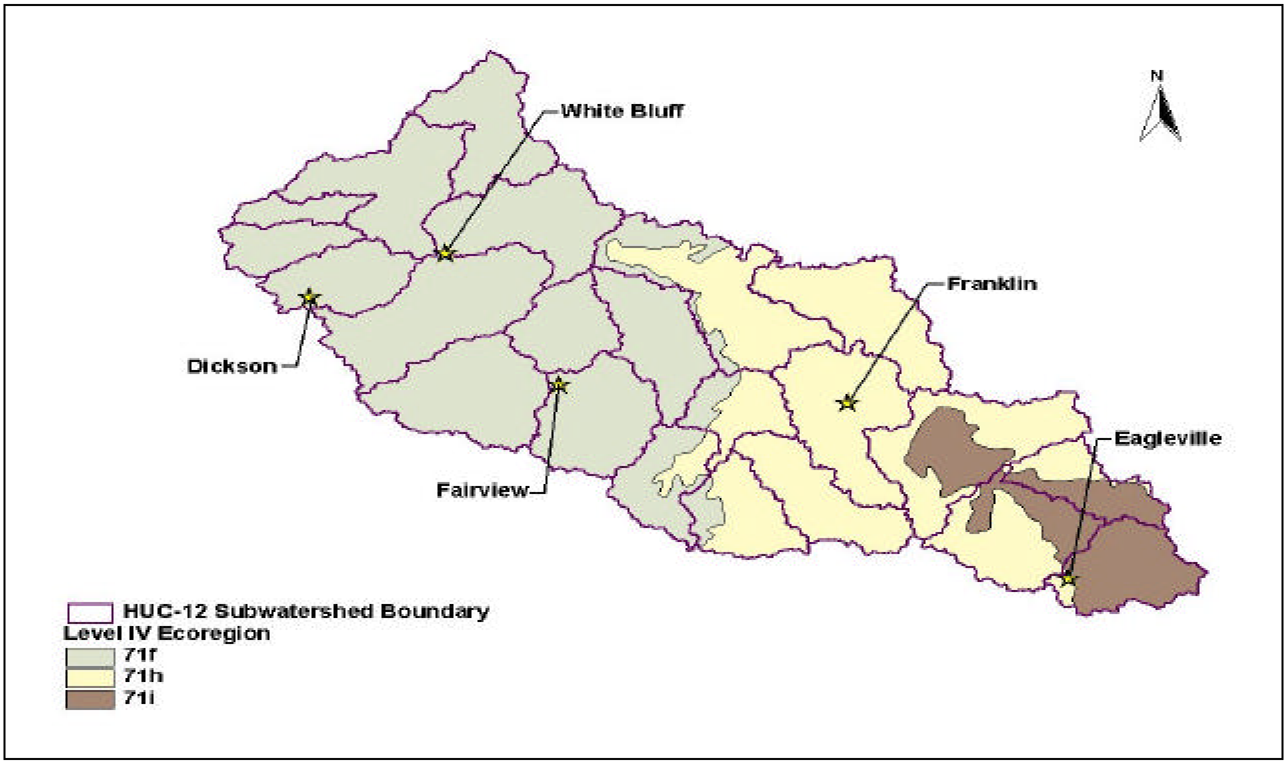

Figure 2 Level IV Ecoregions in the Harpeth River Watershed

Note: TMDL analysis will performed on a HUC-12 subwatershed basis. HUC-12 subwatershed boundaries are shown in figures for reference.

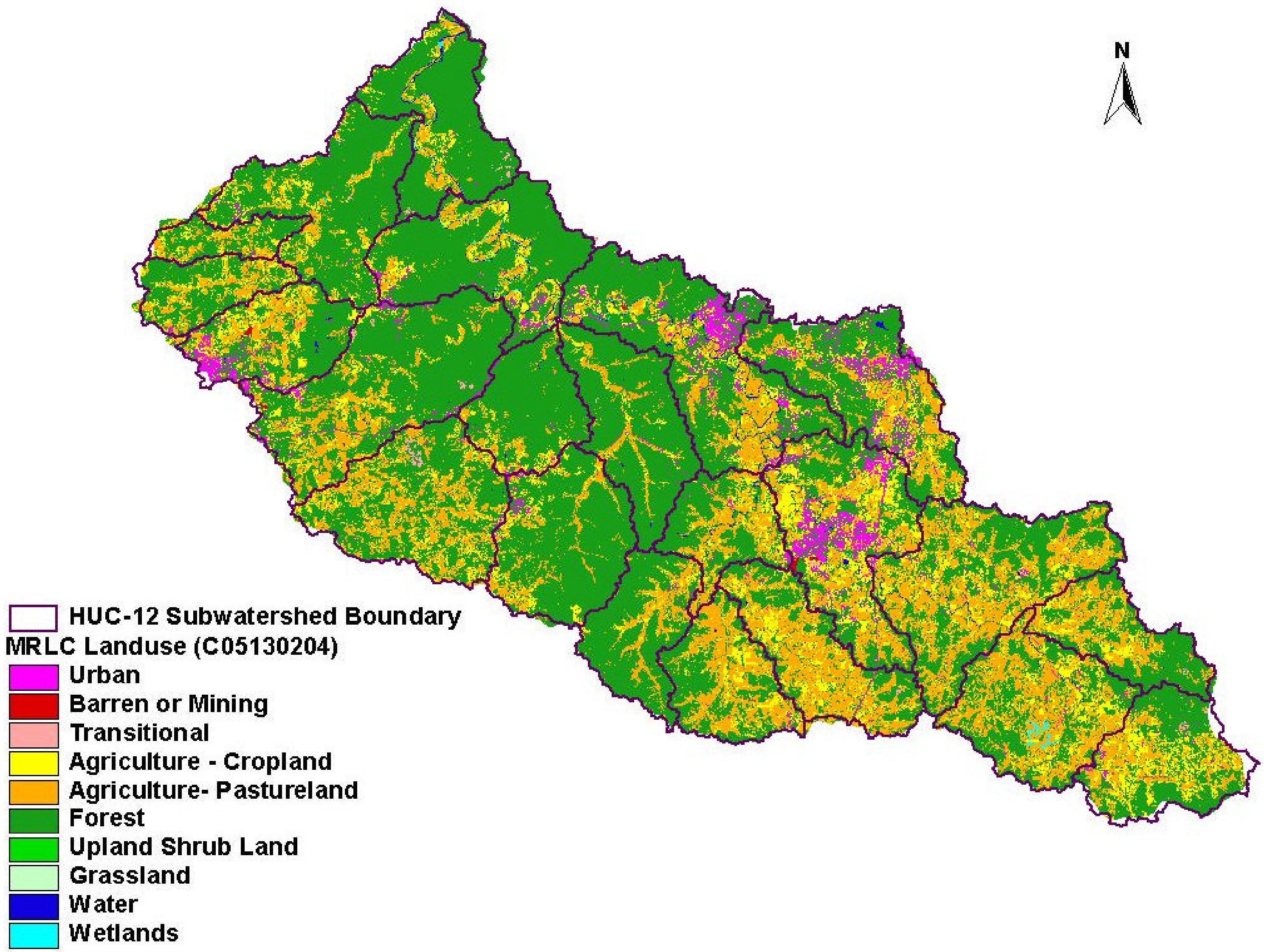

Figure 3 MRLC Land Use Distribution in the Harpeth River Watershed

Table 3 MRLC Land Use Distribution – Harpeth River Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay		
Deciduous Forest	278,592	50.1
Emergent Herbaceous Wetlands	13	0.0
Evergreen Forest	13,984	2.5
High Intensity Commercial/Industrial/ Transportation	5,035	0.9
High Intensity Residential	1,214	0.2
Low Intensity Residential	10,373	1.9
Mixed Forest	54,820	9.9
Open Water	2,189	0.4
Other Grasses (Urban/recreational)	8,192	1.5
Pasture/Hay	130,294	23.4
Quarries/Strip Mines/ Gravel Pits	325	0.1
Row Crops	49,041	8.8
Transitional	1,074	0.2
Woody Wetlands	758	0.1
Total	**555,904**	**100.0**

Problem Definition

The State of Tennessee's final 1998 303(d) list (TDEC, 1998) was approved by the U.S. Environmental Protection Agency (EPA), Region IV on September 17, 1998. The list identified a number of waterbodies in the Harpeth River watershed as not fully supporting designated use classifications due to organic enrichment/DO (see Table 1). The designated use classifications for the Harpeth River and its tributaries include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Some waterbodies in the watershed are also classified for industrial water supply and/or domestic water supply.

When used in the context of waterbody assessments, the term organic enrichment can be used to describe a condition of pollution resulting from several possible factors:

- Organic enrichment can mean the accumulation of organic (carbon containing) materials in a stream. Organic materials naturally accumulate in streams in the form of detritus or debris from the surrounding area. It can also refer to bio-solid materials that have escaped from wastewater treatment processes. In either case, the organic materials will decompose over time through bacterial respiration. Respiration is an oxygen consuming process. Therefore, if large amounts of organic material decompose with little flow or oxygen exchange, a condition of low dissolved oxygen could occur resulting in impairment to stream biology.

- Organic enrichment has also been used to describe the eutrophication effects of high nutrient discharges from point or nonpoint sources. This phenomenon is more appropriately classified as nutrient enrichment. Nutrient rich waters entering streams can cause abundant algae growth. The right combination of nutrients, algae, and sunlight may result in extreme dissolved oxygen fluctuations in the stream. Oxygen is produced during photosynthesis and consumed during respiration and decomposition. Because it requires light, photosynthesis occurs only during daylight hours. At night, photosynthesis may not counterbalance the loss of oxygen through respiration and decomposition resulting in the decline of dissolved oxygen concentrations (TDEC, 2003).

- The algae growth that occurs with organic enrichment can also have adversely affect the instream habitat. When the algae becomes choking to fish and aquatic life, it blocks available sunlight to organisms in the substrate. It also covers up and blocks organisms from potential usable habitat.

Concerning the 1998 §303(d) listing of waters identified in Table 1, TDEC used the term "Organic enrichment/DO" to describe impairment from: 1) low dissolved oxygen (DO) levels; 2) excessive enrichment from one or more of the three factors described above; or 3) a combination of low dissolved oxygen levels and excessive enrichment. As part of its 1998 §303(d) listing process, TDEC conducts assessments of its waters using water quality data, biological data, and field observation data concerning the presence or absence of excessive algae. For the first water listed in Table 1 (i.e., the Harpeth River from its headwaters to its confluence with the West Harpeth River), the §303(d) listing was based on low dissolved oxygen levels as well as biological assessment data that indicated stressed biota. Concerning all of the other waters in the Harpeth River watershed, the §303(d) listings were based on observations of stressed biota during biological surveys as well as the observation of excessive algae. For all of the 1998 §303(d)-listed in Table 1 with the exception of the mainstem of the Harpeth River, there were no observations of low dissolved oxygen levels in the data that was used for the basis of the §303(d) listings.

The interrelationship of major kinetic processes associated with instream dissolved oxygen is shown schematically in Figure 4. A more detailed discussion of the relationship between nutrients and water quality is presented in Appendix A.

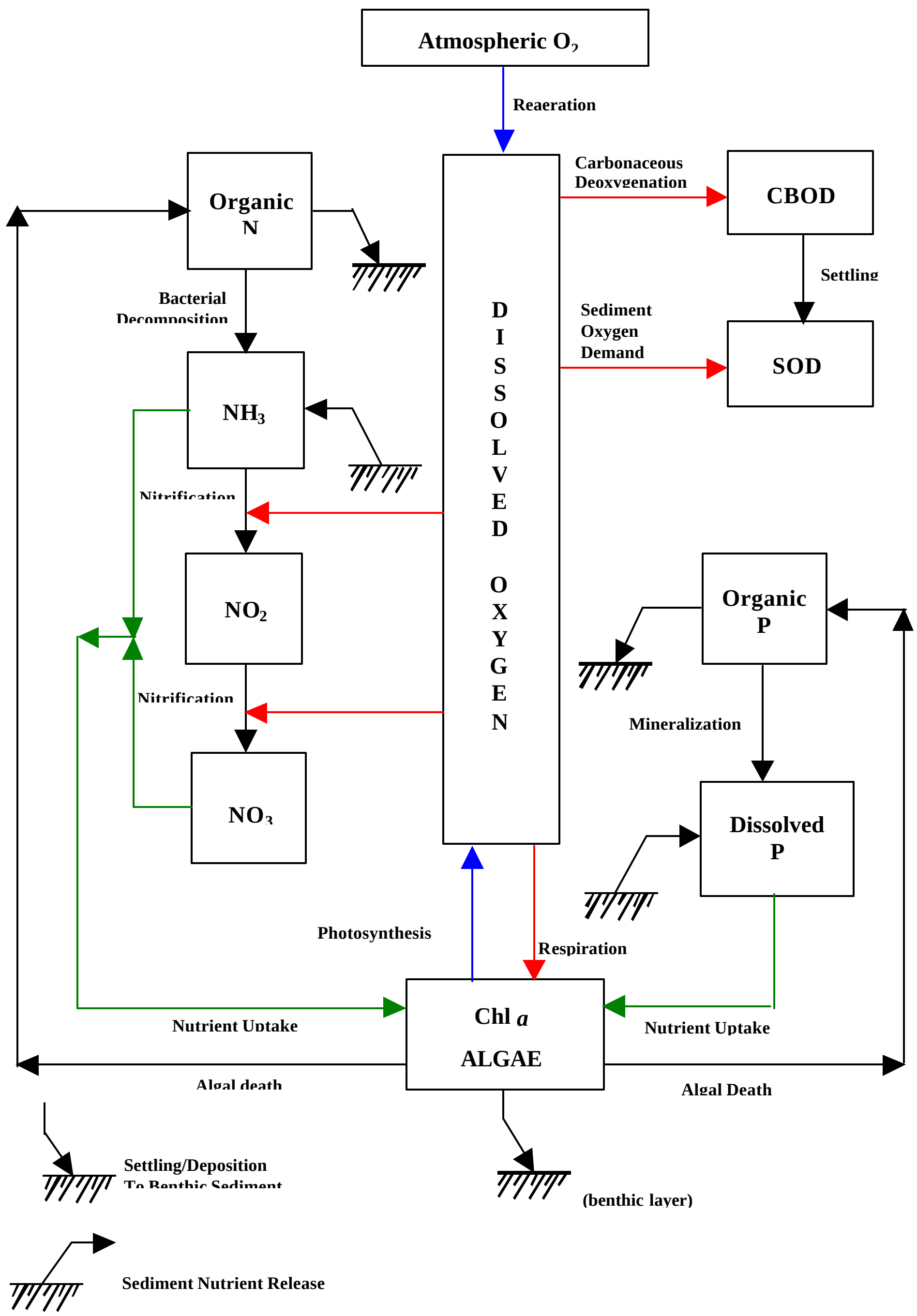

Figure 4 **Interrelationship of Major Kinetic Processes Associated with Instream Dissolved Oxygen (USEPA, 1997a)**

Water Quality Studies Conducted Prior to 2000

Prior to intensive field survey work conducted on the Harpeth River by EPA and TDEC from 2000 to 2002, the available water quality data in the Harpeth River watershed was mostly limited, and much of it was limited to the Harpeth River in the vicinity of the City of Franklin Sewage Treatment Plant (STP). Most of the data consisted of grab samples taken from the mainstem of the Harpeth River over a period of several years where parameters such as temperature, dissolved oxygen (DO), conductivity, pH, 5-day biochemical oxygen demand (BOD5), and ammonia nitrogen (NH3-N) were measured.

Water quality studies had been conducted on the Harpeth River, but many of these studies had been conducted more than 15 years ago. The State of Tennessee had conducted some of these studies, and the focus of their studies was the segment of the Harpeth River immediately downstream from discharge from the City of Franklin STP. The State's studies generally included the collection of water quality samples such as DO, dissolved oxygen (DO), BOD_5, and NH_3-N. The Environmental and Water Resources Engineering program at Vanderbilt University conducted some water quality studies on the Harpeth River in 1977 (Davis et al, 1977) and 1986 (Sulkin, 1987). In 1977, water quality sampling was conducted including diurnal DO measurements, and hydraulic measurements were made in the Harpeth River from RM85.3 to RM82.0 and RM58.3 to RM54.2. In 1986, hydraulic data was collected and water quality sampling was conducted, including diurnal DO measurements, in the Harpeth River from RM85.3 to RM81.6.

Between 1995 and 1999, TDEC conducted additional water quality studies on the Harpeth River during low-flow periods. In 1995, TDEC collected water quality data concurrent with a time-of-travel study on a 2.5-mile segment of the Harpeth River in the vicinity of a wastewater discharge from the City of Franklin. In 1998 and 1999, TDEC collected diurnal DO data downstream of a 0.2 MGD discharge from the Lynnwood STP (at RM 77.9 of the Harpeth River).

Data collected prior to 2000 provided a limited understanding concerning the "organic enrichment/DO" impairment of the Harpeth River watershed. Although the available data provided some level of understanding of the DO processes in the Harpeth River immediately downstream from the Franklin STP, a very small amount of data was available in the portion of the watershed located upstream from the City of Franklin's STP. Based on the available data, it was apparent that low dissolved oxygen levels in the Harpeth River occurred during low-flow conditions. However, the extent and significance of the impairment was not well understood.

Water Quality Studies Conducted in 2000 - 2002

In fulfilling its commitments as part of the Settlement Agreement, EPA undertook a study of the Harpeth River watershed from the Sneed Road crossing (i.e., RM 66.0 of the Harpeth River) to the headwaters. As a result, the extent of this study needed to include the 1998 303(d)-listed segment of the Harpeth River (from the headwaters to the confluence with the West Harpeth River) as well as a 12.7-mile segment located immediately downstream from this segment. Considering the existence of a USGS gage located at RM62.4, EPA determined it would extend the study down to that point. The purpose of conducting the study was to: 1) characterize water quality conditions and assess pollutant sources contributing to the impairment of the Harpeth River; and 2) analyze contributions of nutrients and oxygen-consuming loads to the Harpeth River watershed as part of the TMDL process.

EPA Region 4 designed and conducted 6 field studies of the Harpeth River, with significant assistance from TDEC, between July 2000 and April 2001. The data and information collected during these studies can be found in EPA's draft report, "Harpeth River Modeling Data Report: December 2001." The activities conducted during these studies were as follows:

1. <u>July 28-31, 2000 : reconnaissance (recon) study</u> The purpose of the recon was to gain an understanding of the system sufficient to design an effective low-flow water quality study. An additional objective was added to the scope of the recon when EPA learned of a raw wastewater overflow at the Spencer Creek lift station, near the mouth of Spencer Creek that occurred on July 23, 2000. It became important to obtain water quality data on the River before the sewage spill had an impact. Grab samples were collected at stations between RM114.6 and RM62.4 and included the analysis the nitrogen series, total phosphorus, and total organic carbon.

2. <u>August 21-26, 2000 : low-flow study</u> The study focused on the oxygen producing and consuming processes in the Harpeth River and its primary tributaries (Little Harpeth River, West Harpeth River, and Spencer Creek). Measurements were made of stream reaeration rate coefficients downstream from the Franklin STP and the Lynnwood STP. Sediment Oxygen Demand (SOD) measurements were made at stations amenable to in-situ chamber measurements. Water column production and respiration measurements were made along the length of the stream using light and dark bottle technology. Diurnal water quality measurements were made simultaneously at thirteen stations using multi-probe "sonde" instrumentation at half hour intervals over a span of more than thirty consecutive hours. Water quality samples were taken from the Franklin STP, the Lynnwood STP, the mainstem of the River, and the primary tributaries to the River. Meteorological measurements were made during the study including rainfall, wind speed, and wind direction. In addition, cross-section surveys were made at 22 stations along the mainstem of the Harpeth River.

3. <u>August 27-28, 2000 : rainfall runoff study</u> A two-day loading survey was conducted at three USGS gage stations located on the Harpeth River and one USGS gage station located on Spencer Creek. Three water quality samples were collected from each of these stations during the rising and falling limbs of the individual hydrographs.

4. <u>September 20-24, 2000 : follow-up low-flow survey</u> During a follow-up survey, additional time-of travel data was collected in areas upstream and downstream of the segment where the reaeration study had been conducted in August. A source assessment was also conducted in the Spencer Creek watershed. In addition, a longitudinal float survey was conducted from RM88.1 to RM62.4 and withdrawal lines connected to pumps along the river were documented.

5. <u>September 25-28, 2000 : rainfall runoff study</u> A two-day loading survey was conducted at three USGS gage stations located on the Harpeth River and one USGS gage station located on Spencer Creek. Three water quality samples were collected from each of these stations during the rising and falling limbs of the individual hydrographs.

6. <u>April 16-20, 2001 : medium-flow study</u> The study focused on the oxygen producing and consuming processes in the Harpeth River and its primary tributaries (Little Harpeth River, West Harpeth River, and Spencer Creek) during approximately average environmental conditions (i.e., the flows and temperatures during the springtime were anticipated to be close to the annual average values). It was assumed that these conditions would also reflect the combined impact of point sources and nonpoint sources. Measurements were made of diffusion, which could be correlated

to reaeration rate coefficients. Water column production and respiration measurements were made along the length of the stream using light and dark bottle technology. Diurnal water quality measurements were made simultaneously at sixteen stations using multi-probe "sonde" instrumentation at half hour intervals over a span of more than thirty consecutive hours. Water quality samples were taken from the Franklin STP, the Lynnwood STP, the Cartwright Creek Utility District STP (discharges to RM68.8), the mainstem of the River, and 12 tributaries to the Harpeth River. In addition, meteorological measurements were made during the study including rainfall, wind speed, and wind direction.

During 2002, TDEC measured diurnal dissolved oxygen fluctuations during summer low flow conditions at several locations on the Harpeth River between the confluence of the Little Harpeth River and the South Harpeth River. Measurements were obtained at 30-minute intervals during the periods from 8/2/02 through 8/9/02 and 9/11/02 through 9/25/02 at RMs 45.0, 63.3, 79.8, 84.4, and near RM 88.0. This data (see Appendix B) show a significant diurnal fluctuation with periodic deviations from the minimum concentration of 5 mg/l specified by State water quality standards.

Assessment of Water Quality and Pollution Sources

A significant amount of information was learned from the Harpeth River dataset collected in between 2000 and 2002. Observations in the field as well as assessments of the data collected contributed to the decisions relating to the development of the models used for the TMDL development effot. The important field observations and aspects of the water quality and pollution source assessments are described as follows:

- The Harpeth River appears to be a gaining-losing stream (i.e., there is significant interflow between the river and groundwater), at least in one area of the watershed during low flow conditions. During the July 2000 reconnaissance, a 150-meter segment of the Harpeth River channel, located immediately downstream from the low-head dam at RM89.2, was observed to be completely dry. However, there were no other observed hydraulic discontinuities in the system.

- As mentioned in the "Dischargers and Withdrawals" section of this report, at least 21 pumps potentially withdraw water from the Harpeth River between RM88.1 and RM62.4. Considering the apparent sizes of the pumps, they would probably not have any significant impact on the flow in the river unless the majority of them were operating simultaneously during low-flow conditions. It is believed that the vast majority of these pumps were not operating during the periods when the low-flow studies were conducted and therefore did not have any significant impact on flow, travel time, or water quality.

- The algae that exists in the Harpeth River appears to be dominated by periphyton. There is no significant presence of macrophytes in the Harpeth River, and the chlorophyll a and nutrient levels measured in the water column were very low (**Table 4**). However, the magnitudes of the diurnal swings in DO were indicative of significant algal productivity and respiration (**Figure 5** and **Figure 6**).

- As indicated by algal growth potential tests conducted during the August 2000 study, the Harpeth River appears to be predominantly a nitrogen-limited system during low flows. As indicated by the

April 2000 study, however, the limiting nutrient varies from station to station during higher flow conditions.

- The City of Franklin STP discharges a significant amount of nutrient loads and BOD loads to the Harpeth River. In terms of effluent concentration, however, the nitrogen and BOD levels in the treated wastewater are very low (**Table 4** and **Table 5**).

- During the August 2000 study in the vicinity of RM114.6, a dead calf was observed in the river. (The sampling at this station was conducted upstream from any influence that the dead calf may have had on water quality.) Although this is certainly not something that EPA or TDEC would attempt to simulate in a model, it is recognized that this may be an indicator that the agricultural best management practices in the headwaters of the Harpeth River watershed need improvement.

- During the August 2000 study, the lowest levels of DO in the watershed were observed in the headwaters (i.e., RM114.6) as demonstrated in **Figure 5**. The average DO values generally increased in the downstream direction. In addition, the highest BOD concentrations in the system during the August 2000 study (**Table 4**) as well as the April 2001 study (**Table 5**) were also observed at RM114.6.

- The DO levels in the mainstem of the Harpeth River during the April 2001 study were all above 8.0 mg/l. It is likely that the DO levels in the system are only problematic during low-flow and high temperature conditions.

- Some of the measured DO levels in the Harpeth River at RM62.4 (downstream from the §303(d)-listed segment) were below TDEC's water quality standard for dissolved oxygen of 5.0 mg/l. Therefore, EPA and TDEC decided to extend the model down to RM32.4 (the location of a downstream USGS gage station).

- Based on the available data, the primary sources of BOD in the watershed appear to be: 1) the City of Franklin STP; and 2) agricultural areas in the headwaters. Based on the available data, the sources of nutrient loads appear to be fairly well distributed throughout the watershed.

- Use of a hydrodynamic model upstream from RM88.1 is not practical. The observed low flows in the upper Harpeth River watershed (frequently below 1.0 cubic feet per second) combined with the observed slow travel times result in a significant stability issue with regard to hydrodynamic modeling.

- Based on the available data and information collected from the Little Harpeth River and the mainstem of the Harpeth River (from its confluence with the West Harpeth River to its confluence with the South Harpeth River), the three water quality limited segments identified in **Table 2** and identified on the State's 2002 §303 list require TMDLs. EPA and TDEC are in agreement that the development of TMDLs for the 2002 listed segments should be addressed concurrently with the development of TMDLs for waters impaired for organic enrichment/DO on the 1998 §303 list.

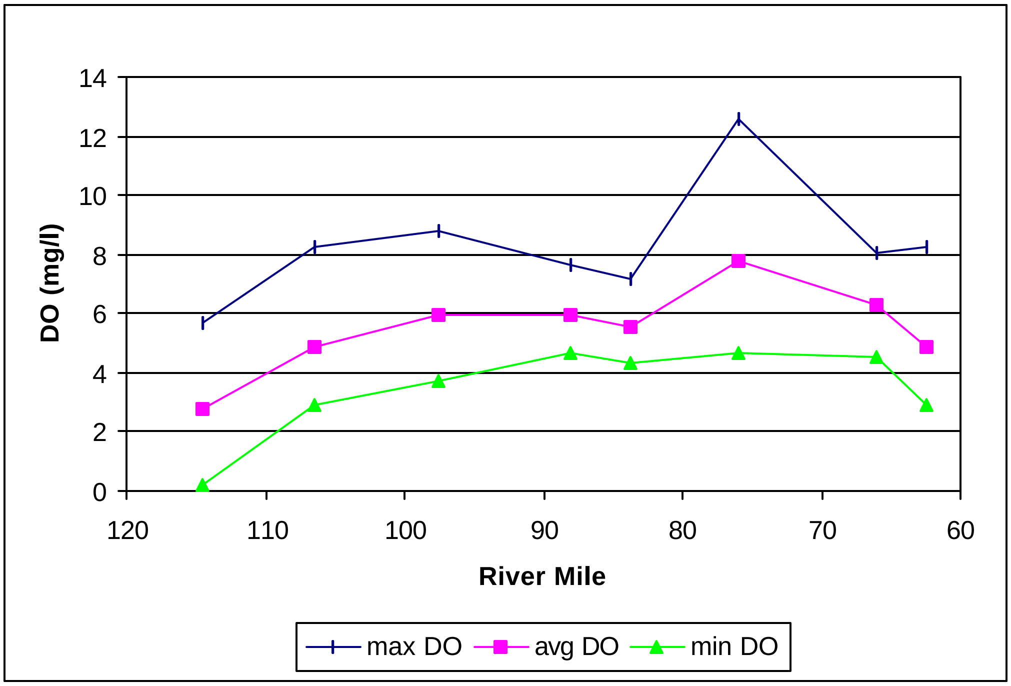

Figure 5 Longitudinal DO profile during the August 2000 study

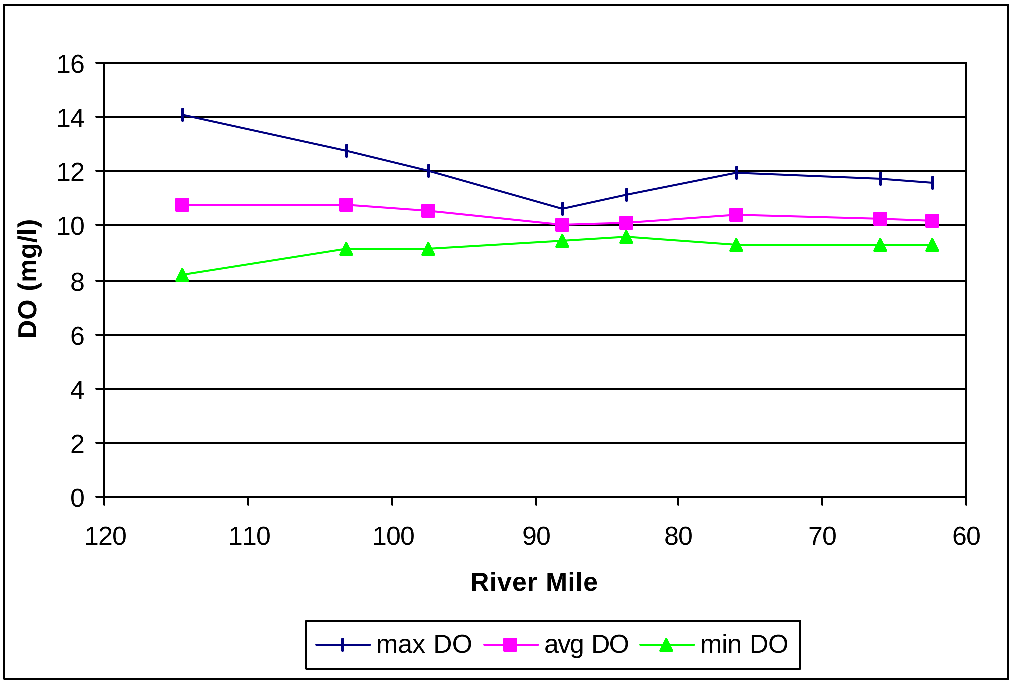

Figure 6 Longitudinal DO profile during the April 2001 study

Table 4 Water quality data collected in August 2000

Station	Flow(cfs)	UltimateC BOD (mg/l)	NH_3-N(mg/l)	NO_2/NO_3 (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)	Chl a (ug/l)
RM114.6	0.02	7.13	0.06	0.05	0.84	0.89	0.09	5
RM106.5	0.03	5.61	0.08	0.19	0.64	0.83	0.25	-
RM97.5	0.03	3.56	0.03	0.05	0.54	0.59	0.26	-
RM88.1	2.6	0.98	0.09	0.29	0.42	0.71	0.28	0.64
Spencer C	1.9	2.72	0.05	0.29	0.47	0.76	0.36	2.75
RM84.4	9.0	3.78	0.09	1.20	0.70	0.77	1.30	1.28
W. Harp R	0.5	2.36	0.07	0.05	0.24	0.29	0.24	2
RM76.0	12.8	3.5	0.04	0.57	0.37	0.94	0.67	2.6
RM66.0	10.9	3.62	0.06	0.36	0.48	0.84	0.43	-
L. Harp R	0.03	1.73	0.05	0.13	0.50	0.63	0.31	6.4
RM62.4	12.0	1.78	0.07	0.31	0.39	0.70	0.46	3.8
Franklin STP	4.96	5.53	0.06	1.90	1.0	2.90	1.8	-
Lynnwood STP	0.24	16.96	0.11	10.0	1.4	11.4	4.0	-

Table 5 Water quality data collected in April 2001

Station	Flow (cfs)	UltimateC BOD (mg/l)	NH_3-N (mg/l)	NO_2/NO_3 (mg/l)	TKN (mg/l)	Total N (mg/l)	Total P (mg/l)	Chl a (ug/l)
RM114.6	24.4	5.25	< 0.05	0.71	0.25	0.96	0.06	0.47
Arrington C	17.5	2.15	< 0.05	0.65	0.15	0.80	0.30	1.43
RM103.1	109	2.64	< 0.05	0.64	0.21	0.85	0.19	0.96
Starnes Cr	5.7	4.46	< 0.05	0.76	0.21	0.97	0.28	0.90
RM97.5	139	4.92	< 0.05	0.70	0.18	0.88	0.20	0.7
5mile Cr	10.4	2.75	< 0.05	1.30	0.2	1.50	0.40	1.73
Watson Br	4.9	3.81	< 0.05	0.79	0.225	1.01	0.34	2.06
RM88.1	178	4.08	< 0.05	0.83	0.23	1.06	0.25	1.48
Spencer C	7.2	3.93	< 0.05	1.10	0.20	1.30	0.27	2.37
RM84.4	213	3.43	< 0.05	1.00	0.24	1.24	0.29	1.28
W. Harp R	130	2.26	< 0.05	0.88	0.15	1.03	0.18	1.26
RM76.0	369	3.04	< 0.05	0.99	0.25	1.24	0.25	0.89
L. Harp R	39.3	3.31	< 0.05	1.20	0.16	1.36	0.22	0.78
RM62.4	503	2.84	< 0.05	0.95	0.27	1.22	0.26	1.24
Franklin STP	6.18	11.94	< 0.05	2.70	0.94	3.64	0.70	-
Lynnwood STP	0.21	13.07	0.051	4.50	0.83	5.33	1.1	-
Cartwright Cr STP	0.52	8.2	< 0.05	9.20	0.67	9.87	1.5	-

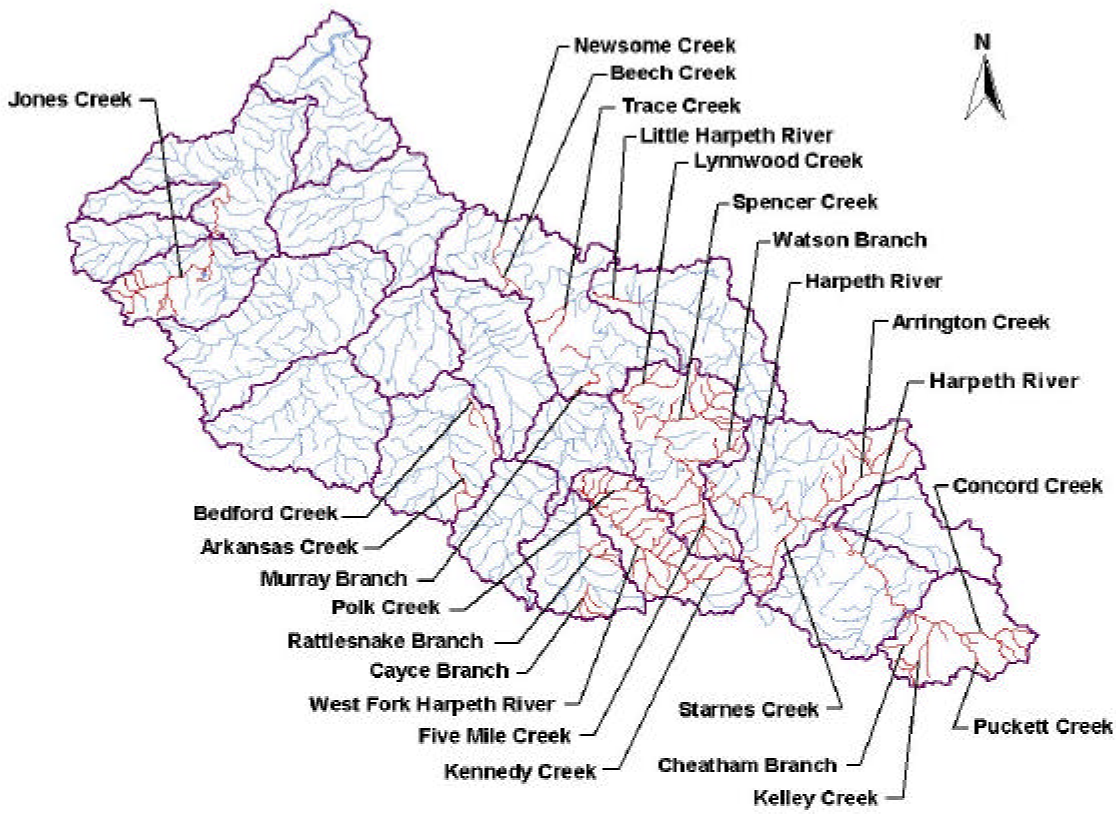

Figure 7 Waterbodies identified on the State's 303(d) List for Organic Enrichment/DO

Target Identification

Water Quality Criteria

Several narrative criteria, applicable to organic enrichment/nutrients, are established in *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October 1999 (TDEC, 1999)*:

Applicable to all use classifications (recreation shown):

> Solids, Floating Materials, and Deposits – There shall be no distinctly visible solids, scum, foam, oily slick, or the formation of slimes, bottom deposits or sludge banks of such size and character that may be detrimental to fish and aquatic life.
>
> Other Pollutants – The waters shall not contain other pollutants that will be detrimental to fish or aquatic life.
>
> Dissolved Oxygen (except for fish & aquatic life)– There shall be sufficient dissolved oxygen

present to prevent odors of decomposition and other offensive conditions.

Applicable to the fish & aquatic life use classification:

> Biological Integrity - The waters shall not be modified through the addition of pollutants or through physical alteration to the extent that the diversity and/or productivity of aquatic biota within the receiving waters are substantially decreased or adversely affected, except as allowed under 1200-4-3-.06. The condition of biological communities will be measured by use of metrices suggested in guidance such as Rapid Bioassessment Protocols for Use in Streams and Rivers (EPA/444/4-89-001) or other scientifically defensible methods. Effects to biological populations will be measured by comparisons to upstream conditions or to appropriately selected reference sites in the same ecoregion (See definition).

In addition, numerical dissolved oxygen criteria are specified for the protection of fish & aquatic life:

> Dissolved Oxygen - The dissolved oxygen shall be a minimum of 5 mg/l except in limited sections of streams where it can be clearly demonstrated that (i) the existing quality of the water due to irretrievable man-induced conditions cannot be restored to the desired minimum of 5 mg/l dissolved oxygen; or (ii) the natural background quality of the water is less than the desired minimum of 5 mg/l. Such exceptions shall be determined on an individual basis, but in no instance shall the dissolved oxygen concentration be less than 3 mg/l. The dissolved oxygen concentrations shall be measured at mid-depth in waters having a total depth of ten (10) feet or less, and at a depth of five (5) feet in waters having a total depth of greater than ten (10) feet. The dissolved oxygen concentration of recognized trout waters shall not be less than 6.0 mg/l. The above criteria are applicable to tailwaters. The dissolved oxygen concentration of trout waters which have been designated as supporting a naturally reproducing population shall not be less than 8.0 mg/l.

These TMDLs are being proposed at levels necessary to attain the fish and aquatic life designated use, as well as all other designated uses associated with the waters included in Table 1 and Table 2.

TMDL Target

Water Quality Endpoint: Dissolved Oxygen

For all waters in the Harpeth River watershed, the minimum dissolved oxygen concentration of 5 mg/l specified for the protection of fish and aquatic life will be used as the target for the mainstem of the Harpeth River. Specifically, this target is applied to that 303(d)-listed segments where DO levels have been observed.

Table 6 303(d) listed segments targeted with a water quality endpoint of dissolved oxygen

Waterbody ID	Impacted Waterbody	Length of Impairment
TN05130204009-2000	HARPETH RIVER From South Harpeth River to the Little Harpeth River	18.8 miles
TN05130204009-2000	HARPETH RIVER From Little Harpeth River to the West Harpeth River	16.8 miles
TN05130204021-1000	LITTLE HARPETH RIVER From Harpeth River to Otter Cr	4.1 miles
TN05130204016 (1998)	HARPETH RIVER From W Fk Harpeth to headwaters	37.3 miles

Water Quality Endpoint: Nutrients

In order for a TMDL to be established at protective levels for waters where organic enrichment is preventing attainment of designated uses, a numeric "target" protective of the uses of the waterbody must be identified to serve as the basis for the TMDL. Where State regulation provides a numeric water quality criterion for the pollutant, such as dissolved oxygen, the criteria is the basis for the TMDL. Where state regulation does not provide a numeric water quality criterion at present, as in the case of organic enrichment, a numeric interpretation of the narrative water quality standard must be determined.

One of the three methods mentioned in *Nutrient Criteria Technical Guidance Manual, Rivers and Streams* (USEPA, 2000) that can be used in developing nutrient criteria is the reference stream reach approach. Reference reaches are relatively undisturbed stream segments that can serve as examples of the natural biological integrity of a region. One of the ways to establish a target for TMDL development is the selection of a percentile from the distribution of primary variables of known reference systems. Primary variables include total nitrogen (TN), total phosphorus (TP), chlorophyll *a*, and turbidity or total suspended solids (TSS). EPA recommends the use of the 75th percentile value as the reference condition.

For the purposes of this TMDL, and in accordance with the standard for biological integrity, the 75th percentile values of total nitrogen (TN) and total phosphorus (TP) data collected at Tennessee's Level IV ecoregion reference sites were determined to be the appropriate numeric interpretation of the narrative water quality standard. The watersheds corresponding to these reference sites are considered the "least impacted" in the ecoregion and, as such, nutrient loading from these subwatersheds may serve as the appropriate basis for the TMDL target. Detailed information regarding Tennessee ecoregion reference sites can be found in *Tennessee Ecoregion Project, 1994-1999* (TDEC, 2000). The nutrient concentration goals, corresponding to the 75th percentile data for Level IV ecoregions 71f, 71h, & 71i are:

Level IV Ecoregion	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)
71f	0.310	0.018
71h	0.728	0.060
71i	0.755	0.160

Table 7 303(d) listed segments targeted with a water quality endpoint of nutrient concentrations

Waterbody ID	Impacted Waterbody	Length of Impairment
TN05130204021-1000	LITTLE HARPETH RIVER From Harpeth River to Otter Creek	4.1 miles
TN05130204 016	HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr	79.0 miles
TN05130204 016	HARPETH RIVER TRIBUTARIES Concord Cr, Puckett, Cheatham, Kelley, portion of Harpeth headwaters	35.7 miles
TN05130204 009	HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting	10.4 miles
TN05130204 009	HARPETH RIVER TRIBUTARIES Beech and unn. Trib to Harpeth are not supporting	5.7 miles
TN05130204 013	WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting	62.1 miles
TN05130204 013	W. FORK HARPETH TRIBUTARIES Rattlesnake Branch is not supporting	6.5 miles

Source Assessment

An important part of TMDL analysis is the identification of individual sources, or source categories of pollutants in the watershed that that cause or contribute to the organic enrichment and low dissolved oxygen impairment in the watershed. Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by two broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities (WWTFs); and 2) NPDES regulated industrial and municipal storm water discharges. A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of these TMDLs, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDLs must provide Load Allocations (LAs) for these sources.

Point Sources

NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contains the primary nutrients nitrogen (organic nitrogen, ammonia, nitrate, & nitrite) and phosphorus (organic & inorganic) as well as substances that exert a biochemical oxygen demand (BOD) on the receiving waters of the effluent discharges. The BOD discharged from these WWTFs is composed of carbonaceous BOD (CBOD) and nitrogenous BOD, respectively reflecting the oxygen demanding substances associated with carbon and nitrogen.

There are 19 NPDES permitted WWTFs in the Harpeth River watershed that discharge wastewater containing BOD and nutrients. The location of these facilities is shown in Figure 8. These WWTFs discharge varying levels of BOD, nitrogen, and phosphorus. Permit limits and monitoring requirements for selected effluent characteristics are summarized in Tables 8 & 9 for those facilities that are located in HUC-12 subwatersheds containing waterbodies impaired for organic enrichment/low dissolved oxygen. A summary of effluent monitoring data, submitted on Discharge Monitoring Reports (DMRs), from the larger facilities (design flow $\geq$ 0.25 MGD) is presented in Table 9.

As part of the TMDL development effort, many of the 19 NPDES permitted WWTFs in the Harpeth River watershed were determined not to cause or contribute to violations of water quality standards for the segments addressed by this TMDL. For each discharge, this determination was made based on factors including: 1) the WWTF discharges to a water that is not impaired and is not expected to cause or contribute to a downstream impairment; 2) the WWTF was determined through a modeling or technical analysis not to cause or contribute to an impairment. Specifically, the NPDES facilities that discharge significant loads of the pollutants of concern are receiving a wasteload allocation in this TMDL and are identified in Table 10.

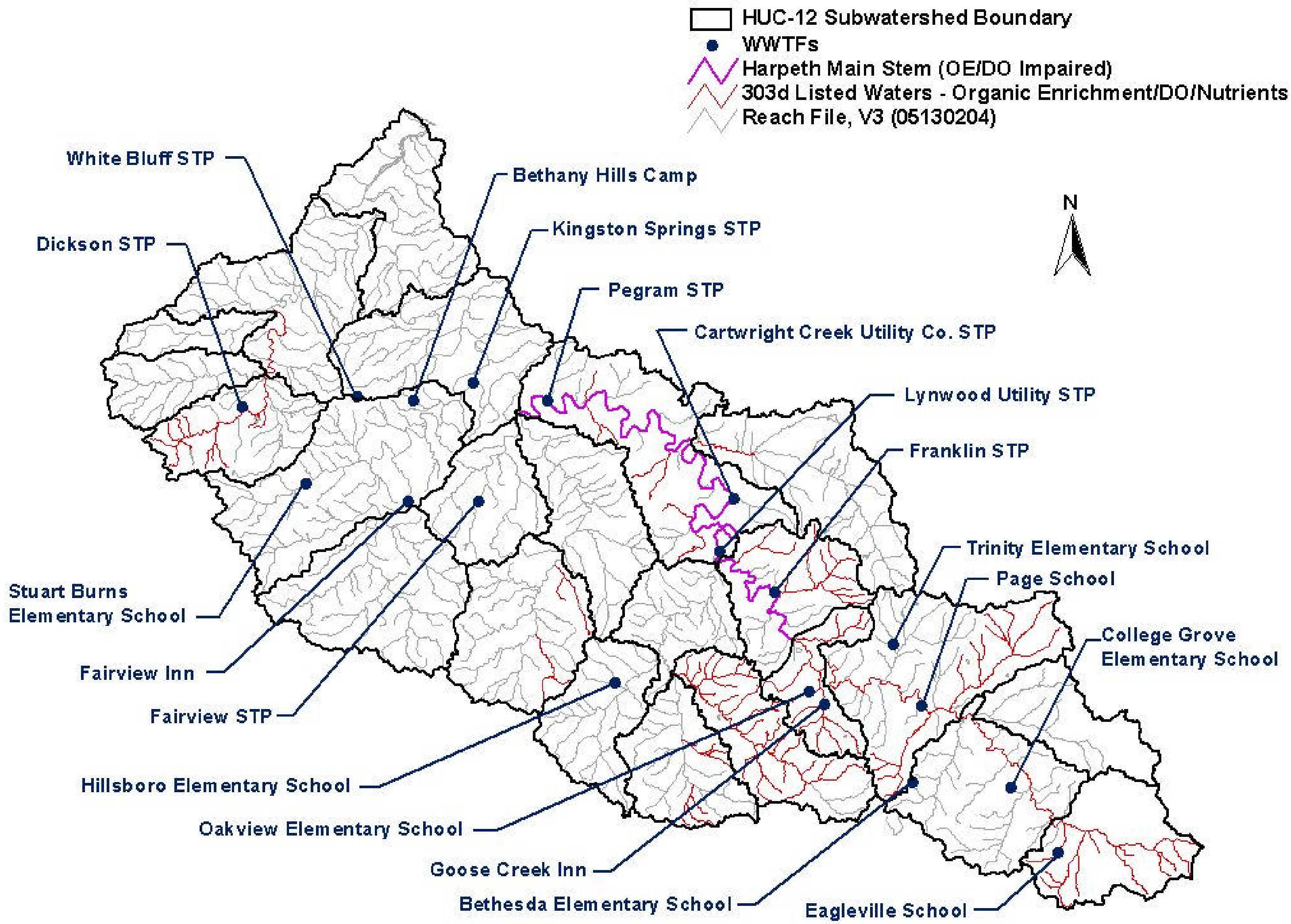

Figure 8 NPDES Permitted Wastewater Treatment Facilities with Discharges Containing BOD or Nutrients

Table 8 NPDES Permit Limits for WWTFs Discharging BOD or Nutrients to Subwatersheds with Waterbodies Impaired for Organic Enrichment/Low Dissolved Oxygen

NPDES Permit No.	Facility	Design Flow [MGD]	Effluent Characteristic	Season [a]	NPDES Permit Limits: Monthly Average [mg/l]	Monthly Average [lbs/day]	Weekly Average [mg/l]	Weekly Average [lbs/day]	Daily Maximum [mg/l]
TN0027278	Cartwright Creek Utility Co. STP	0.250	$CBOD_5$	S	5	10	7.5	16	10
				W	10	21	15	31	20
			NH_3-N	S	2	4	3	6	4
				W	5	10	7.5	16	10
			DO	Y	6.0 mg/l minimum instantaneous				
TN0029718	Lynwood Utility STP	0.400	$CBOD_5$	S	5	17	7.5	25	10
				W	10	33	15	50	Report
			NH_3-N	S	2	7	3	10	4
				W	5	17	7.5	25	10
			DO	Y	6.0 mg/l minimum instantaneous				
			T. Nitrogen [b]	S	3	10	4.5	15	6
			T. Phosphorus	S	Report	—	—	—	—
TN0067873	Oakview Elementary School	0.010	$CBOD_5$	Y	10	—	—	—	15
			NH_3-N	S	2	—	—	—	3
				W	5	—	—	—	7.5
			DO	Y	6.0 mg/l minimum instantaneous				
TN0074586	Pegram STP	0.050	$CBOD_5$	S	15	6	20	8	25
				W	25	10	35	15	40
			NH_3-N	S	6	3	9	4	12
				W	15	6	20	8	25
			DO	Y	3.0 mg/l minimum instantaneous				
TN0057789	Eagleville School	0.018	$CBOD_5$	Y	10	—	—	—	20
			NH_3-N	S	2	—	—	—	4
				W	5	—	—	—	10
			DO	Y	6.0 mg/l minimum instantaneous				

NPDES Permit Limits for WWTFs Discharging BOD or Nutrients to Subwatersheds with Waterbodies Impaired for Organic Enrichment/Low Dissolved Oxygen (continued)

NPDES Permit No.	Facility	Design Flow [MGD]	Effluent Characteristic	Season [a]	NPDES Permit Limits: Monthly Average [mg/l]	Monthly Average [lbs/day]	Weekly Average [mg/l]	Weekly Average [lbs/day]	Daily Maximum [mg/l]
TN0057835	Page School	0.020	$CBOD_5$	S	4	—	—	—	8
				W	25	—	—	—	40
			NH_3-N	S	1	—	—	—	3
				W	5	—	—	—	10
			DO	Y	6.0 mg/l minimum instantaneous				
TN0060216	Goose Creek Inn	0.030	$CBOD_5$	Y	10	—	—	—	20
			NH_3-N	S	2	—	—	—	4
				W	5	—	—	—	10
			DO	Y	6.0 mg/l minimum instantaneous				
TN0064297	Trinity Elementary School	0.013	$CBOD_5$	Y	10	—	—	—	20
			NH_3-N	S	2	—	—	—	4
				W	3	—	—	—	5
			DO	Y	6.0 mg/l minimum instantaneous				
TN0064475	Bethesda Elementary School	0.013	$CBOD_5$	S	15	—	—	—	30
				W	20	—	—	—	35
			NH_3-N	S	1.5	—	—	—	3
				W	3	—	—	—	5
			DO	Y	3.0 mg/l minimum instantaneous				
TN0067164	College Grove Elementary School	0.012	$CBOD_5$	Y	10	—	—	—	15
					25	—	—	—	35
			NH_3-N	S	1	—	—	—	1.5
				W	5	—	—	—	7.5
			DO	Y	5.0 mg/l minimum instantaneous				

Notes: a. Seasonal abbreviations: S = Summer (5/1 through 10/31); W = Winter (11/1 through 4/30); Y = Entire Year.

b. Total nitrogen limits are under appeal as of 11/5/02.

Table 9 NPDES Permit Limits - Franklin STP (TN0028827)

Period Applicable	Design Flow [MGD]	Effluent Characteristic	Season [a]	NPDES Permit Limits: Monthly Average [mg/l]	Monthly Average [lbs/day]	Weekly Average [mg/l]	Weekly Average [lbs/day]	Daily Maximum [mg/l]
Normal Flow Discharge Mode [b] through 5/31/04	5.5	$CBOD_5$	S	6	275	9	413	12
			W	10	459	15	688	20
		NH_3-N	S	0.4	18	0.6	28	0.8
			W	1.5	69	2.3	106	3.0
		DO	Y	8.0 mg/l minimum instantaneous				
		T. Nitrogen [c]	Y	Report	—	—	—	—
		T. Phosphorus	Y	Report	—	—	—	—
High Flow Discharge Mode [d] through 5/31/04	5.5	$CBOD_5$	Y	25	Report	30	Report	35
		NH_3-N	Y	5	Report	7.5	Report	10
		DO	Y	6.0 mg/l minimum instantaneous				
		T. Nitrogen [c]	Y	Report	—	—	—	—
		T. Phosphorus	Y	Report	—	—	—	—
All discharges from 6/1/04 through 11/30/06	12.0	$CBOD_5$	S	6	601	9	901	12
			W	10	1001	15	1500	20
		NH_3-N	S	0.4	40	0.6	60	0.8
			W	1.5	150	2.3	230	3.0
		DO	Y	8.0 mg/l minimum instantaneous				
		T. Nitrogen [c]	S	5.0	—	—	—	—
			W	Report	—	—	—	—
		T. Phosphorus	Y	Report	—	—	—	—

Notes: a. Seasonal abbreviations: S = Summer (5/1 through 10/31); W = Winter (11/1 through 4/30); Y = Entire Year.

b. Normal Discharge Mode: Monthly average effluent flow ≤ 5.5 MGD; or
Monthly average stream flow < 42 MGD (65 cfs), summer; or
Summer dilution ratio < 8:1; or
Monthly average stream flow < 23 MGD (36 cfs), winter; or
Winter dilution ratio < 4.5:1

c. Permittee must comply with a seasonal average of 377 lbs/day for the period 5/1 through 10/31.

d. High Flow Discharge Mode: Monthly average effluent flow > 5.5 MGD; and
Monthly average stream flow ≥ 42 MGD (65 cfs), summer; and
Summer dilution ratio ≥ 8:1; or
Monthly average stream flow ≥ 23 MGD (36 cfs), winter; and
Winter dilution ratio ≥ 4.5:1

Table 9 Summary of Discharge Monitoring Reports

Facility	Effluent Characteristic	Season	Description	DMR Category				
				Monthly Average Concen.	Monthly Average Amount	Weekly Average Concen.	Weekly Average Amount	Daily Maximum Concen
				[mg/l]	[lbs/day]	[mg/l]	[lbs/day]	[mg/l]
Lynwood Utility STP (TN0029718)	CBOD5 (8/00 – 5/03)	S	Minimum	2.3	4.0	3.0	2.5	3.0
			Average	3.1	5.0	3.4	6.5	4.5
			Maximum	4	7.4	5	20.7	9
			POC [a]	0	0	0	0	0
		W	Minimum	2.8	4.2	3.0	5.2	3.0
			Average	4.2	7.8	5.7	12.5	10.1
			Maximum	8.4	15.8	12	31.8	22
			POC [a]	0	0	0	1	1
	NH3 (1/98 – 5/03)	S	Minimum	0.1	0.1	0.1	0.1	0.1
			Average	2.7	4.6	7.0	3.2	6.0
			Maximum	20.6	27.7	32.8	23.1	31.9
			POC [a]	10	4	9	8	12
		W	Minimum	0.1	0.1	0.1	0.1	0.1
			Average	2.7	4.1	4.6	6.6	6.1
			Maximum	19	31	25.8	40.7	30
			POC [a]	5	3	6	3	6
	Total Nitrogen (6/00 – 5/03)	S	Minimum	0.1	0.1	0.1	0.1	0.1
			Average	6.6	7.6	13.3	11.6	16.1
			Maximum	20.4	24.1	44.6	38	56
			POC [a]	c	C	c	c	c
	Total Phosphorus	S	Minimum	¾	¾	¾	¾	¾
			Average	¾	¾	¾	¾	¾
			Maximum	¾	¾	¾	¾	¾
			POC [a]	NA	¾	¾	¾	¾
	DO [b] (1/98 – 5/03)	Y	Minimum	3.5	¾	¾	¾	¾
			Average	7.8	¾	¾	¾	¾
			Maximum	9.9	¾	¾	¾	¾
			POC [a]	1	¾	¾	¾	¾

Summary of Discharge Monitoring Reports (Continued)

Facility	Effluent Characteristic	Season	Description	DMR Category				
				Monthly Average Concen.	Monthly Average Amount	Weekly Average Concen.	Weekly Average Amount	Daily Maximum Concen
				[mg/l]	[lbs/day]	[mg/l]	[lbs/day]	[mg/l]
Franklin STP (TN0028827)	CBOD5 (2/99-4/03)	S	Minimum	1.1	41.5	0.9	13.0	2.0
			Average	2.5	83.9	3.2	119.1	5.9
			Maximum	5.1	190.2	6.5	256.2	10.6
			POC [a]	0	0	0	0	0
		W	Minimum	0.8	48.3	1.2	59.3	2.0
			Average	2.1	112.2	2.9	194.1	4.7
			Maximum	5.8	231.6	8.6	523.8	13
			POC [a]	0	0	0	0	0
	NH3-N (2/99-4/03)	S	Minimum	0.005	0.2	0.006	0.3	0.01
			Average	0.07	2.1	0.11	3.6	0.25
			Maximum	0.44	8.6	0.78	24.9	2.1
			POC [a]	1	0	1	0	1
		W	Minimum	0.015	0.6	0.02	0.6	0.035
			Average	0.22	9.1	0.36	16.9	0.86
			Maximum	3.3	102.9	6.1	174.8	12.4
			POC [a]	1	1	1	1	1
	Total Nitrogen (2/99-4/03)	S	Minimum	0.8	¾	¾	¾	¾
			Average	2.9	¾	¾	¾	¾
			Maximum	9.1	¾	¾	¾	¾
			POC [a]	NA	¾	¾	¾	¾
	Total Phosphorus (2/99-4/03)	S	Minimum	0.01	¾	¾	¾	¾
			Average	0.69	¾	¾	¾	¾
			Maximum	3.4	¾	¾	¾	¾
			POC [a]	NA	¾	¾	¾	¾
	DO [b] (2/99-4/03)	Y	Minimum	7.7	¾	¾	¾	¾
			Average	8.3	¾	¾	¾	¾
			Maximum	9.6	¾	¾	¾	¾
			POC [a]	1	¾	¾	¾	¾

Summary of Discharge Monitoring Reports (Continued)

Facility	Effluent Characteristic	Season	Description	DMR Category				
				Monthly Average Concen. [mg/l]	Monthly Average Amount [lbs/day]	Weekly Average Concen. [mg/l]	Weekly Average Amount [lbs/day]	Daily Maximum Concen [mg/l]
Cartwright Creek Utility Co. STP (TN0027278)	CBOD5 (3/98 – 5/03)	S	Minimum	1	3	1	1	2
			Average	2.0	5.1	3.0	7.6	4.3
			Maximum	5	13	8	25	13
			POC [a]	0	3	1	2	1
		W	Minimum	1	4	2	2	2
			Average	2.4	7.8	3.8	11.5	5.6
			Maximum	8	35	17	64	31
			POC [a]	0	2	1	2	2
	NH3-N (1/98 – 5/03)	S	Minimum	0.2	0	0.2	1.0	0.3
			Average	0.43	1.2	0.87	2.8	1.4
			Maximum	1.5	6	7.6	30	15
			POC [a]	0	1	1	2	1
		W	Minimum	0.1	0	0.2	1.0	0.3
			Average	0.48	1.4	0.65	2.2	1.1
			Maximum	1.2	4	1.5	4	2.7
			POC [a]	0	0	0	0	0
	DO [b] (1/98 – 5/03)	Y	Minimum	6.0				
			Average	7.0				
			Maximum	9.1				
			POC [a]	0				

Notes: a. Number of months with at least one effluent measurement out of compliance with permit limit.

b. Dissolved oxygen is reported as the minimum concentration during the month.

c. Total nitrogen limits are under appeal as of 11/5/02.

Table 10 Wastewater Treatment Facilities receiving a wastleoad allocation in this TMDL

NPDES Permit #	Facility Name	WLA Documentation	Receiving Waterbody
TN0057789	Eagleville School	Table 25	Cheatham Branch
TN0067873	Oakview Elementary School		Unnamed tributary to Fivemile Creek
TN0060216	Goose Creek Inn		Fivemile Creek
TN0028827	Franklin STP	Table 25	Harpeth River
TN0029718	Lynnwood STP	Table 25	Harpeth River
TN0027278	Cartwright Creek Utility Company STP	Table 25	Harpeth River

NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are recognized as point sources of nutrients that potentially cause or contribute to the impairment of organic enrichment/dissolved oxygen. These discharges occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Large and medium MS4s serving populations greater than 100,000 people are required to obtain an NPDES storm water permit. At present, Metro Nashville/Davidson County is the only MS4 of this size in the Harpeth River watershed that is regulated by the NPDES program (TNS068047). As of March 2003, small MS4s serving urbanized areas, or having the potential to exceed instream water quality standards, were required to obtain a permit under the Phase II storm water regulations. An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at 1,000 people per square mile. Franklin, Brentwood, Dickson, Williamson County, and Rutherford County are covered under Phase II of the NPDES Storm Water Program. The Tennessee Department of Transportation (TDOT) is also being issued MS4 permits for State roads in urban areas. Information regarding storm water permitting in Tennessee may be obtained from the TDEC website at http://www.state.tn.us/environment/wpc/stormh2o/

NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002a). Concentrated Animal Feeding Operations (CAFOs) are AFOs that meet certain criteria with respect to animal type, number of animals, and type of manure management system. CAFOs are considered to be potential point sources of nutrient loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* (included as Appendix E), while larger, Class I CAFOs are required to obtain an individual NPDES permit. Requirements of both the general and individual CAFO permits include:

- Development of a Nutrient Management Plan (NMP), and approval of the NMP by the Tennessee Department of Agriculture (TDA).

- Liquid waste handling systems, if utilized, be designed, constructed, and operated to contain all process generated waste waters plus the runoff from a 25-year, 24-hour rainfall event. A discharge from a liquid waste handling facility to waters of the state during a chronic or catastrophic rainfall event, or as a result of an unpermitted discharge, upset, or bypass of the system, shall not cause or contribute to an exceedance of Tennessee water quality standards (see Appendix E, II. for definitions of chronic and catastrophic rainfall events).

- Other Best Management Practices (BMPs).

As of September 30, 2003, there is only one Class II CAFO in the Harpeth River watershed with coverage under the general NPDES permit. The location of this facility is shown in Figure 9. There are no CAFOs with individual permits located in the watershed. It should be noted that the facility is located in a subwatershed containing impaired waterbodies.

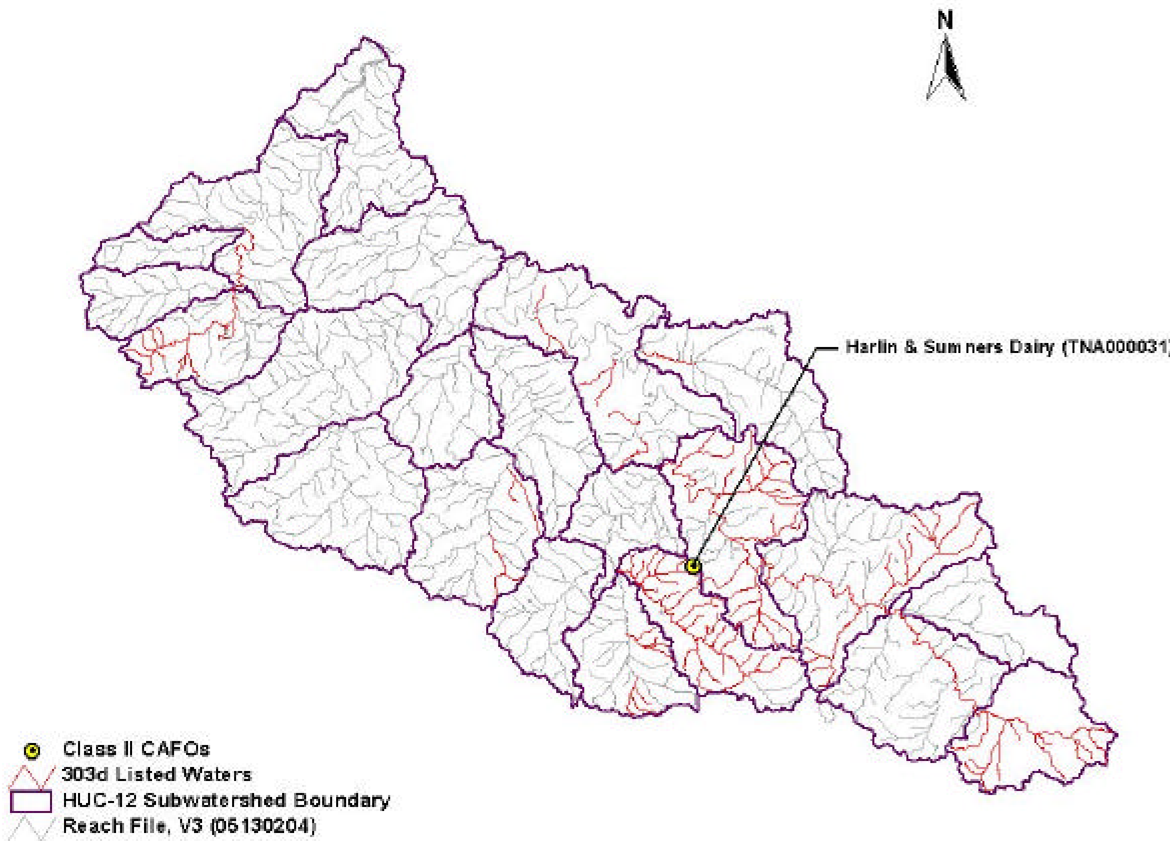

Figure 9 Location of CAFOs in the Harpeth River Watershed

Nonpoint Sources

For many of the waterbodies identified as impaired due to organic enrichment/low dissolved oxygen or nutrients in the Harpeth River watershed, The Tennessee 305(b) report identified nonpoint sources as the principal source of pollution. Possible nonpoint sources of nutrients and organic materials include urban runoff (from areas not covered under an MS4 permit), atmospheric deposition, geology, failing septic systems, and agricultural runoff on land associated with fertilizer application and livestock waste. Typical nutrient loading ranges for various land uses are shown in Table 11. The geology of some watershed areas is dominated by highly phosphatic limestone that creates a significant background source component. Phosphorus can be sorbed to sediment particles, transported to waterbodies, and released to the water column under certain circumstances. This can result in high concentrations of total phosphorus during runoff events, as well as during low flow conditions.

Table 11 Typical Nutrient Loading Ranges for Various Land Uses

Land Use	Total Phosphorus [kg/ha-y]			Total Nitrogen [kg/ha-y]		
	Minimum	Maximum	Median	Minimum	Maximum	Median
Roadway	0.59	1.50	1.10	1.3	3.5	2.4
Commercial	0.69	0.91	0.80	1.6	8.8	5.2
Single Family – Low Density	0.46	0.64	0.55	3.3	4.7	4.0
Single Family – High Density	0.54	0.76	0.65	4.0	5.6	5.8
Multifamily Residential	0.59	0.81	0.70	4.7	6.6	5.6
Forest	0.10	0.13	0.11	1.1	2.8	2.0
Grass	0.01	0.25	0.13	1.2	7.1	4.2
Pasture	0.01	0.25	0.13	1.2	7.1	4.2

Source: Horner et al., 1994 in *Protocol for Developing Nutrient TMDLs* (USEPA 1999).

Table 12 Livestock Distribution in the Harpeth River Watershed

HUC-12 Subwatershed (05130204__)	Livestock Population (1997 Census of Agriculture)						
	Beef Cow	Cattle	Milk Cow	Chickens		Hogs	Sheeps
				Layers	Broilers Sold		
0101	2,515	5,264	325	9	95,085	133	53
0102	3,161	6,238	302	7	0	298	83
0104	3,544	6,843	297	7	0	390	99
0105	1,903	3,675	160	4	0	210	53
0201	2,489	4,806	209	5	0	274	70
0202	1,769	3,415	148	4	0	195	50
0301	1,108	3,021	93	4	0	146	31
0302	1,219	2,599	102	3	0	136	34
0401	784	1,513	66	2	0	86	22
0601	0	2,394	0	5	28	172	3
0604	0	1,846	0	4	21	133	2

Table 13 Population on Septic Systems in the Harpeth River Watershed

HUC-12 Subwatershed (05130204__)	Population On Septic Systems
0101	6,844
0102	3,030
0104	2,727
0105	2,209
0201	1,640
0202	1,365
0301	5,292
0302	8,545
0401	2,465
0601	1,917
0604	2,947

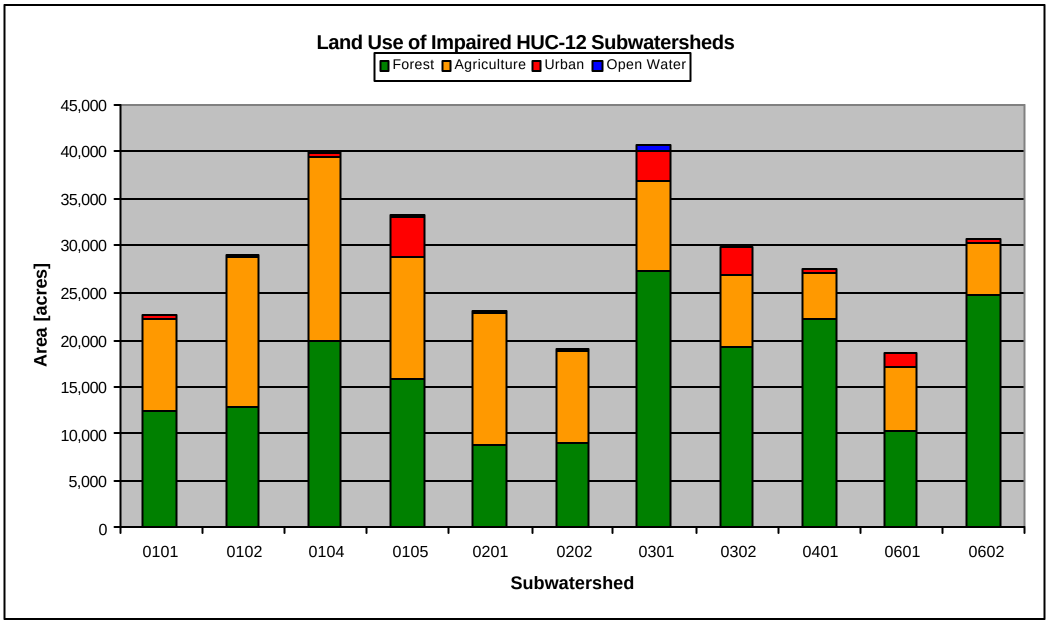

Figure 10 Land Use Area of Impaired HUC-12 Subwatersheds

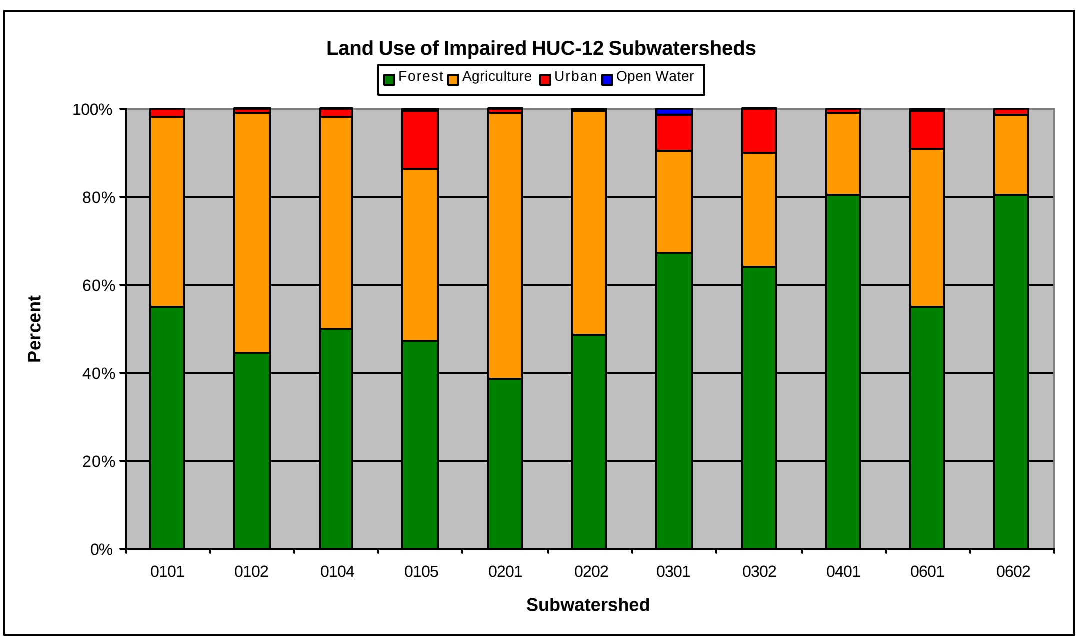

Figure 11 Land Use Percentage of Impaired HUC-12 Subwatersheds

From consideration of the data presented in Tables 12, 13, 14, & F-1 and Figures 3, 10, and 11, several observations can be made:

- Subwatersheds 0101, 0102, 0104, 0105, 0201, and 0202 have significant livestock populations and relatively high percentages of agricultural land. Agricultural sources are a significant source of nutrient loading.
- Subwatersheds 0105, 0301, and 0302 have relatively high percentages of urban land uses. Urban land has the highest loading rates for both phosphorus and nitrogen. Urban land use is concentrated in Franklin (0105), Brentwood (0302), and Metro Nashville-Davidson County (0301 & 0302) which are MS4 Phase I or Phase II urbanized areas.
- Subwatersheds 0101, 0301, and 0302 have the highest populations on septic systems. Failing septic systems can be a significant source of nutrients.

Development of Total Maximum Daily Load

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. Conceptually, a TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS) which takes into account any uncertainty concerning the relationship between effluent limitations and water quality. The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

Development of Nutrient TMDLs

Scope of Nutrient TMDLs

Nutrient TMDLs were developed for all waters identified in Table 7. These TMDLs were developed using a subwatershed approach that involved an analysis of 12-digit hydrologic unit area watersheds. Specifically, nutrient reductions in these subwatersheds are necessary in order for water quality standards to be attained for the waters included in Table 7. The relationship between these impaired segments and the 12-digit subwatersheds that drain to these segments are described in Table 14.

Table 14 Relationship between Impaired segments and 12-digit subwatersheds

Waterbody ID	Impaired Segments	Corresponding 12-digit subwatersheds
TN05130204021-1000	LITTLE HARPETH RIVER From Harpeth River to Otter Creek	0302
TN05130204 009	HARPETH RIVER TRIBUTARIES Beech and unn. Trib to Harpeth are not supporting	0301
TN05130204 016	HARPETH RIVER TRIBUTARIES Arrington Cr, Spencer Cr, Watson Br, 5-mile Cr, Lynnwood Cr, and Starnes Cr	0104, 0105
TN05130204 016	HARPETH RIVER TRIBUTARIES Concord Cr, Puckett, Cheatham, Kelley, portion of Harpeth headwaters	0101
TN05130204 009	HARPETH RIVER TRIBUTARIES Newsome Cr, Trace Cr, and Murray Branch are partially supporting	0301
TN05130204 013	WEST FORK HARPETH RIVER A portion of West Harpeth, plus Cayce Branch, Polk, and Kennedy Creek are partially supporting	0201
TN05130204 013	W. FORK HARPETH TRIBUTARIES Rattlesnake Branch is not supporting	0202

In addition, based on the available data and information, the low dissolved oxygen levels observed in the Little Harpeth River have been determined to be attributed to nutrient enrichment as opposed to impacts from oxygen demanding substances. Therefore, the TMDL for this water will be expressed in terms of nutrients and will not include allocations for BOD.

Figure 12 HUC-12 Subwatershed Boundaries in the Harpeth River Watershed

TMDL Approach for Addressing Nutrients

Nutrient TMDLs were developed for the selected subwatersheds identified in Problem Definition section of the report and are based on the proposed ecoregion-based nutrient concentrations specified in Water Quality Endpoint: Nutrients according to the procedure described in Appendix G. In order to apply the proposed targets over the range of flow conditions encountered in the Harpeth River watershed throughout the year, TMDLs for total nitrogen and total phosphorus are expressed as monthly average loads during a summer period (May 1 – October 31) and monthly average loads during a winter period (November 1 – April 30). Monthly average loads were considered to be more appropriate than daily loads for representing the development of seasonal algal blooms in streams due to excessive nutrient loading and the associated effects on aquatic life. The proposed nutrient TMDLs necessary to protect against organic enrichment for the waters identified in Table 6 are summarized in Table 15.

Table 15 Nutrient TMDLs for Selected Impaired Subwatersheds

HUC-12 Subwatershed (0513020)	Total Nitrogen		Total Phosphorus	
	Summer * [lbs/month]	Winter * [lbs/month]	Summer * [lbs/month]	Winter * [lbs/month]
0101	4480	12478	916	2541
0104	7335	21966	929	2709
0105	5864	18260	483	1505
0201	4062	12649	335	1042
0202	3026	9119	241	732
0301	6253	18537	489	1468
0302	5275	16425	435	1354

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

Estimates of reductions in existing nutrient loading required to attain water quality standards in selected impaired HUC-12 subwatersheds were calculated using a load duration curve methodology according to the procedure described in Appendix H. These estimated reductions are summarized in Table 16.

Table 16 Estimates of Required Load Reductions for Selected Impaired Subwatersheds

HUC-12 Subwatershed (05130204)	Total Nitrogen (%)	Total Phosphorus (%)
0101	20.0	42.4
0104	20.0	42.4
0105	49.4	83.8
0201	53.1	81.3
0202	53.1	81.3
0301	44.8	82.4
0302	34.3	78.1

Units Used to Express Nutrient Wasteload Allocations (WLAs) and Load Allocations (LAs)

For analysis purposes, WWTFs are considered to discharge continuously at their design flow. Since the discharges from these facilities are considered to be independent of subwatershed drainage area and the occurrence of storm events, WLAs are expressed as monthly average loads during a summer period (May 1 – October 31) and monthly average loads during a winter period (November 1 – April 30). Discharges from MS4s and nonpoint sources, however, are dependent on both drainage area size and precipitation. Therefore, for precipitation induced loading, it is more appropriate to express WLAs for MS4s and LAs for nonpoint sources as average semiannual loads per unit area. Summer and winter semiannual periods were selected to conform to historical permitting practices in Tennessee (i.e., Summer: May 1 – October 31;

Winter: November 1 – April 30).

Nutrient Waste Load Allocations

NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

There are 19 WWTFs in the Harpeth River watershed with individual NPDES permits that require monitoring of nutrients or have the reasonable potential to contribute nutrients to surface waters. Three of these facilities are located in the subwatersheds where they have the potential of impacting waters where a nutrient TMDL target is necessary (i.e., the waters identified in Table 7). Monthly total nitrogen and total phosphorus WLAs for the WWTFs in the selected subwatersheds were developed according to the procedure in Appendix I and are summarized in Table 17:

Table 17 Nutrient WLAs for WWTFs

NPDES Permit No.	Facility	HUC-12 SubWS	WLA Total Nitrogen Summer * [lbs/month]	WLA Total Nitrogen Winter * [lbs/month]	WLA Total Phosphorus Summer * [lbs/month]	WLA Total Phosphorus Winter * [lbs/month]
TN0057789	Eagleville School	0101	45.0	67.6	22.5	33.8
TN0067873	Oakview Elementary School	0105	25.0	37.5	12.5	18.8
TN0060216	Goose Creek Inn	0105	75.1	112.6	37.5	56.3

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

NPDES regulated Municipal Separate Storm Sewer Systems (MS4s) are considered point sources of nutrients. WLAs for Phase I & II urban areas are calculated according to the procedure in Appendix I. Since loading from these entities occurs only in response to storm events, WLAs are expressed as average semiannual loads on a unit area basis and applied according to the subwatershed(s) in which the urban area is located. WLAs for existing and future MS4s located in selected impaired HUC-12 subwatersheds are tabulated in **Table 18**.

Table 18 Nutrient Waste Load Allocations for MS4s

Subwatershed (05130204)	WLAs for MS4s			
	Total Nitrogen		Total Phosphorus	
	Summer * [lbs/ac/month]	Winter * [lbs/ac/month]	Summer * [lbs/ac/month]	Winter * [lbs/ac/month]
0101	0.186	0.521	0.037	0.105
0104	0.173	0.520	0.021	0.063
0105	0.164	0.516	0.012	0.041
0201	0.167	0.521	0.014	0.043
0202	0.152	0.459	0.012	0.037
0301	0.148	0.438	0.012	0.035
0302	0.167	0.521	0.014	0.043

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

CAFOs are not authorized to discharge process wastewater from a liquid waste handling system except during a catastrophic or chronic rainfall event. Any discharges made under these circumstances, or as a result of a system upset or bypass, are not to cause an exceedance of Tennessee water quality standards. Therefore, a WLA of zero has been assigned to this class of facilities.

Nutrient Load Allocations for Nonpoint Sources

Load allocations for nonpoint sources in selected impaired HUC-12 subwatersheds were calculated according to the procedure in Appendix I and are shown in **Table 19**. These LAs are expressed as average semiannual loads on a unit area basis and are numerically equal to the WLAs for MS4s.

Table 19 Nutrient Load Allocations for Nonpoint Sources

Subwatershed (05130204)	Las for Nonpoint Sources			
	Total Nitrogen		Total Phosphorus	
	Summer * [lbs/ac/month]	Winter * [lbs/ac/month]	Summer * [lbs/ac/month]	Winter * [lbs/ac/month]
0101	0.186	0.521	0.037	0.105
0104	0.173	0.520	0.021	0.063
0105	0.164	0.516	0.012	0.041
0201	0.167	0.521	0.014	0.043
0202	0.152	0.459	0.012	0.037
0301	0.148	0.438	0.012	0.035
0302	0.167	0.521	0.014	0.043

* Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

Development of TMDLs to Address Low DO Levels in the Harpeth River Headwaters

The water quality characteristics of the Harpeth River, from its headwaters to RM 89.2, are represented by the Enhanced Stream Water Quality Model (QUAL2E) for the purpose of determining the reductions necessary to achieve DO levels that are consistent with the State's water quality standards. As described in EPA's report, "Harpeth River Watershed Modeling Effort: A Tool for TMDL Development", the mainsteam of the Harpeth River was represented by two separate models because of the hydraulic characteristics of this system. This report can be accessed on EPA's website at **www.epa.gov/region4/water/TMDL**.

The QUAL2E is a comprehensive and versatile one-dimensional, steady-state stream water quality model. It can simulate up to 15 water quality constituents in any combination desired by the user. The model is applicable to dendritic streams that are well mixed. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (longitudinal access of the stream). It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow and outflow (Brown and Barnwell, 1987).

The QUAL2E model was applied to the upper Harpeth River watershed from the headwaters to RM89.2 (**Figure 13**). The intention of the model application was to make best efforts to simulate the processes that impact dissolved oxygen concentrations in the segments of the upper Harpeth River system during low-flow conditions. An attempt to calibrate the model was conducted based on the datasets that were collected by EPA and TDEC during 2000 and 2001. The model was parameterized using this data and information in terms of hydraulic characteristics, CBOD and NBOD decay rates, SOD, and reaeration rates. Details concerning this modeling effort are described in the EPA report entiltled, "Harpeth River Watershed Modeling Effort: A Tool for TMDL Development."

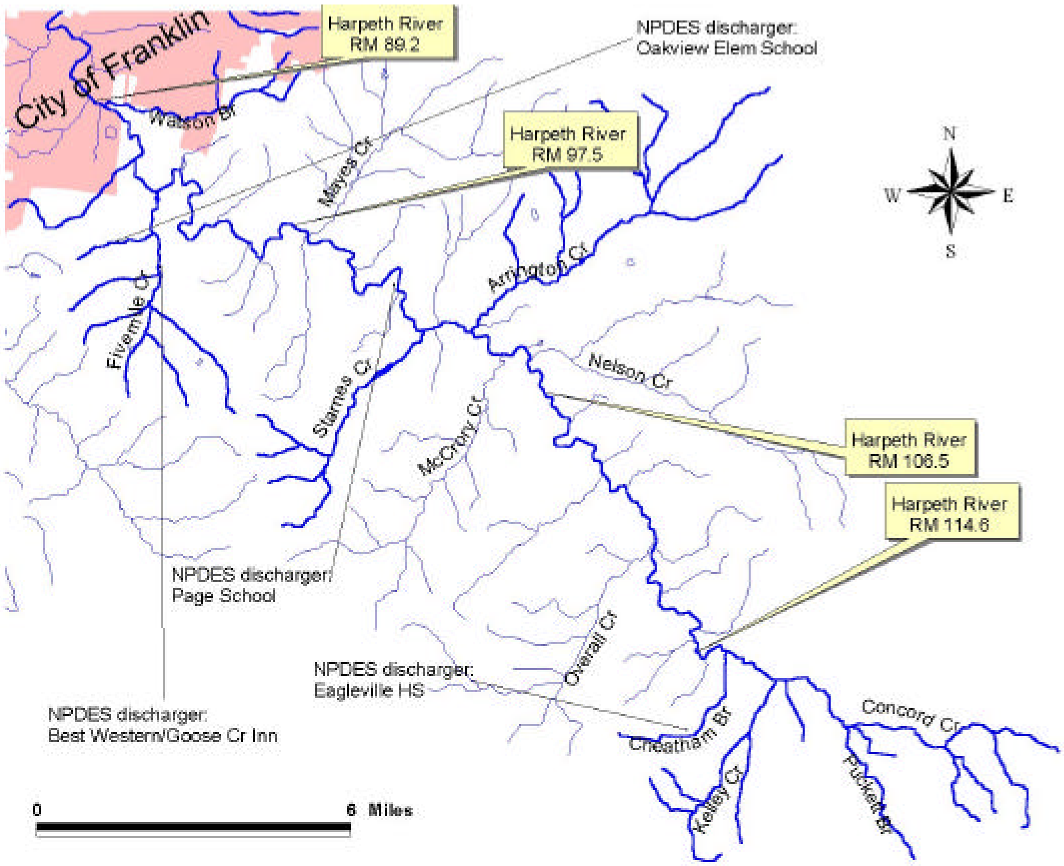

Figure 13 Upper Harpeth River Watershed

Representation of the Harpeth River Headwaters with a QUAL2E Model

The headwaters of the Harpeth River originate from Concord Creek, Puckett Branch, and Kelley Creek. These headwater streams do not receive wastewater discharges from any point sources and they are all located in an area dominated by an agriculture landuse. Therefore these streams are represented, or characterized, as a single headwater reach in QUAL2E. Cheatham Branch is also a headwater stream in an area dominated by an agricultural landuse. However, this stream receives a minor discharge of treated wastewater from Eagleville School and it is included in the model as an individual reach.

The upper Harpeth River receives flows from several other tributaries (Figure 13). It was decided that the tributaries that were impaired from "Organic enrichment/DO" on TDEC's 1998 §303(d) list would be included as individual reaches in the QUAL2E model (i.e., Arrington Creek, Starnes Creek, Fivemile Creek, and Watson Branch). Although there is no evidence that any of these tributaries are impaired from low levels of dissolved oxygen, EPA included them in the model as part of the TMDL analysis. In addition, Fivemile Creek and an unnamed tributary to Fivemile Creek receive minor discharges of treated wastewater respectively from the Best Western/Goosecreek Inn and Oakview Elementary School. These waters were included as individual reaches in the model. The other significant tributaries to the upper Harpeth River (i.e., Overall Creek, Nelson Creek, McCrory Creek, and Mayes Creek) are included in the QUAL2E model as point sources. In addition, Page Middle School discharges treated wastewater to the Harpeth River at RM 101.9 and is included in the model.

A low-head dam and a drinking water intake from the City of Franklin are located in the proximity of RM89.2. During EPA's August 2000 water quality study, a 150-meter segment of the Harpeth River channel located immediately downstream from the low-head dam was observed to be dry. EPA did not attempt to describe or represent any of these characteristics as part of the QUAL2E model. However, considering that observed DO levels increase and observed BOD levels decrease in the downstream direction in the upper portion of the Harpeth River, it is evident that water quality standards in the vicinity of RM89.2 will be met as long as water quality standards are met upstream from this point.

The upper Harpeth River watershed is represented as 15 reaches in the QUAL2E model (**Table 20**). Considering the total length of the system that is modeled as well as the spatial resolution of the available data, the length of each computational element (i.e., Delta X) was selected to be 0.5 miles. Although the QUAL2E model ends at RM88.6, one should be mindful that there are many complex hydraulic processes in the vicinity of RM89.2 that are not simulated (e.g., low-head dam effects on velocity, effects of drinking water intake on flow, the dry portion of the channel).

Table 20 Reaches represented by QUAL2E

Reach number	QUAL2E Reach name	Beginning RM	Ending RM	Headwater reach ( )	Delta X (mile)
1	HR123.1-115.6	123.1	115.6		0.5
2	Cheatham Br	2.5	0		0.5
3	HR115.6-111.1	115.6	111.1		0.5
4	HR111.1-103.6	111.1	103.6		0.5
5	Arrington Cr	8.5	0		0.5
6	HR103.6-102.6	103.6	102.6		0.5
7	Starnes Cr	5.5	0		0.5
8	HR102.6-97.6	102.6	97.6		0.5
9	HR97.6-91.6	97.6	91.6		0.5
10	Fivemile Cr 1	5.0	1.0		0.5
11	UT to Fivemile	1.5	0		0.5
12	Fivemile Cr 2	1.0	0		0.5
13	HR91.6-89.6	91.6	89.6		0.5
14	Watson Br	5.0	0		0.5
15	HR89.6-88.6	89.6	88.6		0.5

Development of TMDL for the Harpeth River Headwaters

The TMDL for the headwaters of the Harpeth River was developed using conservative low flow and high temperatures in the model application. Specifically, a water temperature value of 27 degrees Centigrade and flows equal to the 7-day average, 10-year recurrence interval (7Q10) were applied to the model. The 7Q10 flow for this system was determined based on an area-weighted calculation of a 7Q10 flow published in a U.S. Geological Survey Report for the 7Q10 of the Harpeth River at RM88.1 (USGS, 1995). Specifically, the 7Q10 flow at RM88.1 is 0.5 cubic feet per second (cfs) and the drainage area of the watershed at this station is 191 square miles (mi^2). Based on an area-weighted calculation, the 7Q10 flow per square mile is 0.00262 cfs/mi^2. Using the drainage areas for each of the flow inputs to the QUAL2E model, the 7Q10 for each subwatershed is described in Table 22 and Table 23. It is important to note that these 7Q10 flows are greater than the flows measured and estimated during the August 2000 study, from which the model was parameterized.

In addition, the point sources in the watershed were included in the model as discharging at design capacity at permitted effluent limits for CBOD5 and NH3-N (see Table 8 and Table 23).

Table 21 Headwater 7Q10 flows used for QUAL2E model

Reach number	Reach name	Flow (cfs)
1	HR123.1-115.6	0.082465
2	Cheatham Br	0.005916
5	Arrington Cr	0.049685
7	Starnes Cr	0.052463
10	Fivemile Cr 1	0.021584
11	UT to Fivemile	0.002539
12	Fivemile Cr 2	0.002170
14	Watson Br	0.022497

Table 22 7Q10 flows for point tributaries and NPDES discharges

Point Source/ Tributary	Flow (cfs)
Eagleville School	0.027846
Overall Creek	0.032336
Nelson Creek	0.067917
McCrory Creek	0.030520
Page Middle School	0.031400
Mayes Creek	0.039881
Best Western-Goosecreek Inn	0.046410
Oakview Elementary	0.015470

When running the model during critical conditions, the predicted DO levels in the headwater reaches are as low as 2.65 mg/l (see Figure 14). Based on how the model was parameterized, the model is extremely sensitive to sediment oxygen demand (SOD), relative to carbonaceous or nitrogenous oxygen demand. In addition, removing the minor point source discharges in the model simulations had no effect on the predicted DO levels in the mainstem of the Harpeth. In order for the DO standard to be attained in the Harpeth River headwaters, it is necessary to reduce the SOD in the segment represented by Reach #1 in the model (i.e., the Harpeth River segment upstream from RM 115.6) by 65% (see Figure 15).

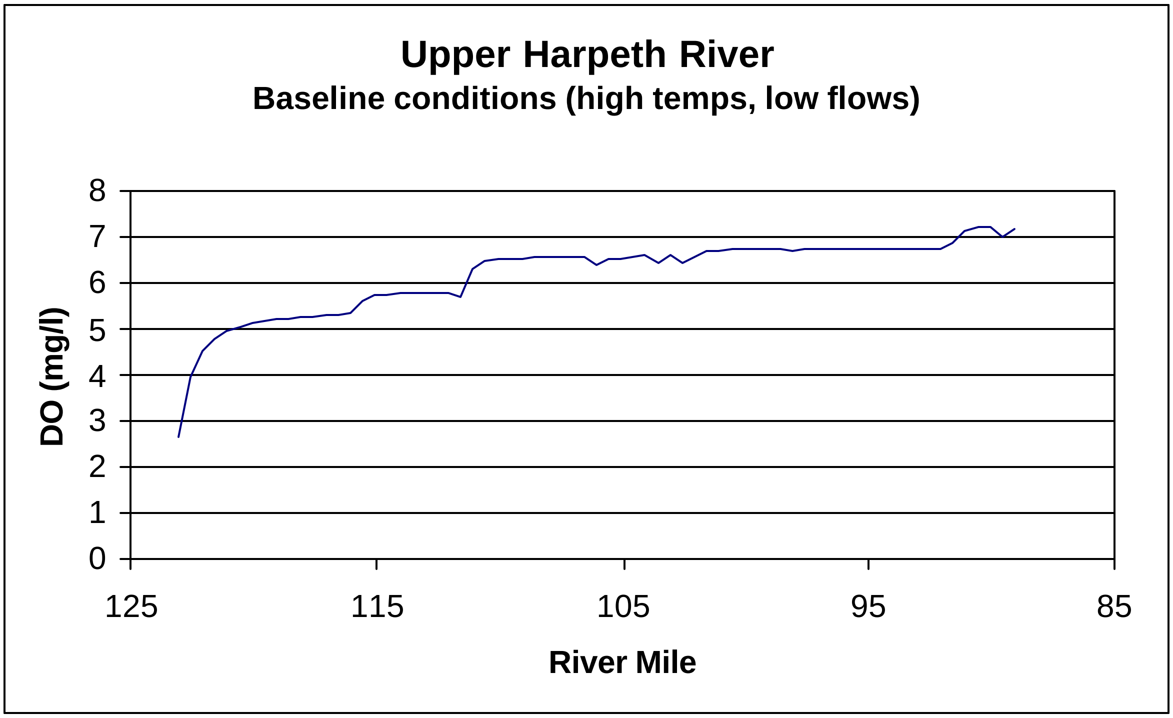

Figure 14 Predicted DO levels for QUAL2E baseline conditions

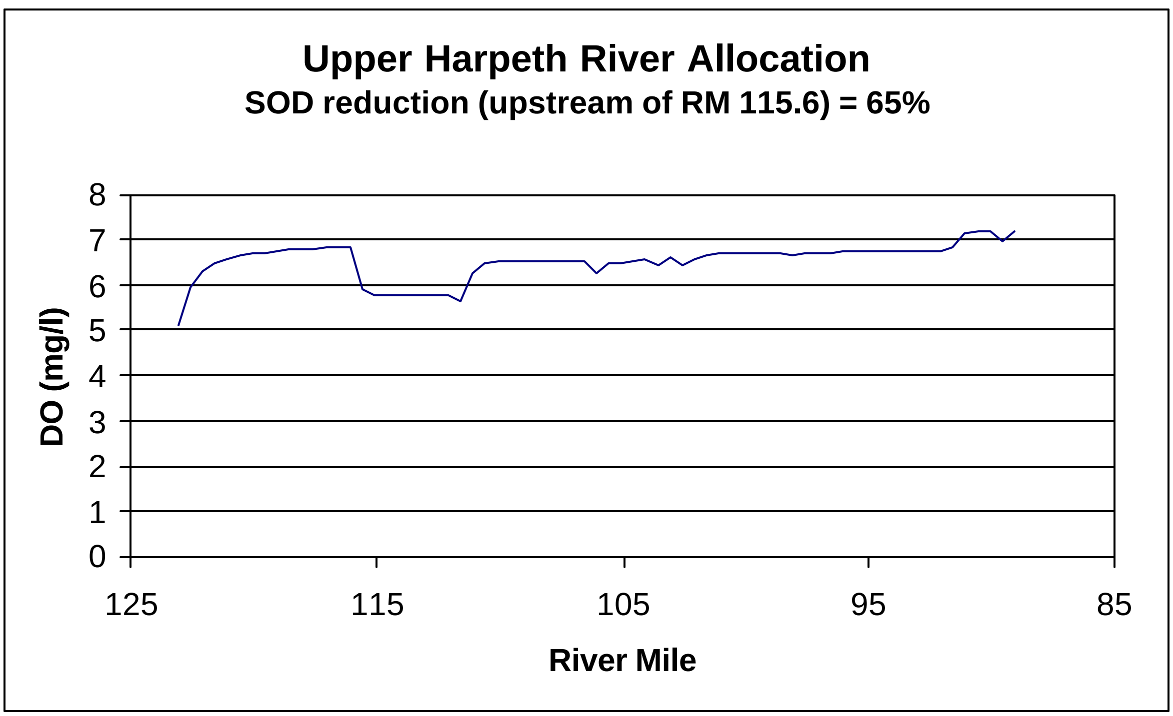

Figure 15 Predicted DO levels for QUAL2E Allocation Run

Allocations for the Upper Harpeth River TMDL

Considering that reductions in NBOD and CBOD in the Harpeth River headwaters are predicted to have an insignificant impact on instream DO level, the allocations are established to achieve an SOD reduction of 65% in the waters upstream from RM 115.6 of the Harpeth River. In order to achieve an SOD reduction of 65%, it is conservatively assumed that external load reductions on the order of 65% will be necessary. It is also conservatively assumed that reductions on the order of 65%, on a long-term average basis, will need to be achieved from nutrient loads (i.e., total phosphorus and total nitrogen) as well as loads from carbon sources (i.e., CBOD). Both the watershed load allocations to control nutrients on a monthly basis to protect the tributaries in the Upper Harpeth River, summarized in Table 19, and the load allocations on an annual average basis to control CBOD and nutrients to attain the dissolved oxygen criterion in the Upper Harpeth River, summarized in Table 24, apply to the subwatershed 051302040101. This will ensure that the summer monthly averages will protect the tributaries as well as attain a greater annual average load reduction than the nutrient TMDL would require alone.

The watershed upstream from RM 115.6 of the Harpeth River can be represented by the 12-digit subwatershed, 05130204 0101 (see Figure 1 and Figure 12). Based on the information that was used to establish the nutrient allocations for this subwatershed, the existing annual nutrient loads are approximated to be 102,000 lbs/year for total nitrogen and 21,000 lbs/year for total phosphorus. If a 65% reduction is applied to these estimated existing loads, the resulting allocation will be 35,700 lbs/year for total nitrogen and 7,350 lbs/year from total phosphorus.

The existing CBOD loads entering the Harpeth River from the 12-digit subwatershed, 05130204 0101, are not well characterized. Therefore, the CBOD allocation will be in terms of a percent reduction and will be consistent with the percent reduction of SOD that is necessary for water quality standards to be attained. Only four NPDES-permitted point sources are in this watershed that require a Wasteload allocation as referenced in Table 10. They are: 1) Eagleville School; 2) Page School; 3) Goose Creek Inn; and 4) Oakview Elementary School. Based on QUAL2E predictions, these facilities are not expected to have any impact on instream DO levels at their permitted limits. In addition, loads from these facilities enter the Harpeth River downstream of RM 115.6. Table 23 and Table 24 include the proposed allocations to ensure attainment of the dissolved oxygen water quality standard in the headwaters of the Harpeth River.

Table 23 Wasteload Allocation to protect DO levels in the headwaters of the Harpeth River

NPDES facility	Summer Total Nitrogen Load [a] (lbs/month)	Winter Total Nitrogen Load [a] (lbs/month)	* Summer Total Phosphorus Load [a] (lbs/month)	* Summer Total Phosphorus Load [a] (lbs/month)	** Total $CBOD_5$ Load [b] (lbs/month)
Eagleville School (TN0057789)	45.0	67.6	22.5	33.8	45.0
Page School (TN0057835)	20.0	69.0	24.0	36.0	20.0
Goose Creek Inn (TN0060216)	69.0	104.0	36.0	54.0	69.0
Oakview Elementary (TN0067873)	23.0	35.0	12.0	18.0	23.0
CAFOs	0	0	0	0	0
MS4s	NA	NA	NA	NA	NA

Notes: a -The allowable nutrient load is consistent with the nutrient allocation provided in Table 18

b – The allowable CBOD5 load is based on the facilities permitted limits

Table 24 Load Allocation to protect DO levels in the headwaters of the Harpeth River

12-digit subwatershed	Total Nitrogen Load (lbs/year)	Total Phosphorus Load (lbs/year)	Total Reduction in CBOD (percent)
05130204 0101	35,700	7,350	65%

Development of TMDLs to address the low dissolved oxygen levels in the Harpeth River from river mile 88.1 to river mile 32.4.

This section of the TMDL addresses the impacts of pollutant sources on dissolved oxygen concentrations in the main-stem Harpeth River. This section of the Harpeth River is subject to a range of flows (less than 1 cfs to more than 20,000 cfs) that have a significant impact on the ability of the River to maintain the 5.0 mg/l dissolved oxygen concentration necessary to achieve the State's water quality standards. Because of the wide range of flow regimes present in the watershed throughout a given year, EPA developed and calibrated a dynamic water quality model for the Harpeth.

Dynamic Model Development by EPA

This model development effort was based upon six field studies of the Harpeth River conducted by EPA Region 4 staff, with significant assistance from TDEC personnel, between July 2000 and April 2002. The resulting system of linked dynamic models consists of three functional parts:

Loading Simulation Program in C++ (LSPC)

CE-QUAL-RIV1

Water Quality Analysis Simulation Program, version 6 (WASP6)

Details of the field studies and development of the linked dynamic models are documented in the "Harpeth River Watershed Modeling Effort: A Tool for TMDL Development, USEPA2002", (TMDL Modeling Report) which is available on our website. A summary of the three components is presented below.

LSPC Model

The Loading Simulation Program in C++ (LSPC) is a comprehensive data management and modeling system that is capable of representing loading, both flow and water quality, from nonpoint and point sources and simulating in-stream processes. LSPC includes the Hydrological Simulation Program – Fortran (HSPF) algorithms for hydrology, sediment, general water quality, and stream transport.

In order to simulate stream flows, watershed loadings, and resulting concentrations of nutrients and BOD in streams, the Harpeth River watershed was divided into subwatersheds as described in the TMDL Modeling Report.

CE-QUAL-RIV1 Model

CE-QUAL-RIV1 is a one dimensional (cross-sectionally averaged hydrodynamic and water quality model, meaning that the model resolves longitudinal variations in hydraulic and water quality characteristics and is applicable where lateral and vertical variations are small. Only the hydraulic component of the model was used in this application. The hydrodynamic model is typically used to predict one-dimensional hydraulic variations in streams with highly unsteady flows that occur in the Harpeth River.

Geomorphic data for modeled sections of the Harpeth River were derived from existing stream cross-sections and interpolated data. The final geometric configuration for the model consisted of 135 cross-sections representing segment lengths of 1848-3000 feet. Upstream boundary flows were obtained from 15-minute flow data at USGS Station 03432500 located at river mile 88.1 near Franklin. In order to maintain model stability, a minimum flow of one cfs was imposed for all upstream boundary flows. Flow data at USGS Station 03434500 (near Kingston Springs at river mile 32.4) was used for the downstream model boundary conditions. LSPC model output data provided the tributary flows for inputs into the CE-QUAL-RIV1 model. Flow from the Franklin WWTP was considered to be significant and included as a point source. Additional data to support the model development included instantaneous measurements of stream flow and stage at selected locations for the monitoring periods of 8/22/2000-8/24/2000 and for 4/18/2001 and time-of-travel studies conducted by TDEC in 1995 and EPA in 2000 and 2001.

The CE-QUAL-RIV1 model was calibrated for flow for the water years 2000 and 2001 using the data described above. A detailed description of the model calibration process and results are presented in the TMDL Modeling Report.

WASP6 Model

The WASP6 model is a dynamic compartment-modeling program for aquatic systems, including both the water column and the under-lying benthos. The time-varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange are represented in the basic program. WASP6 was run using the EUTRO subroutine for conventional water quality analyses to assess the Harpeth River.

The calibrated CE-QUAL-RIV1 model was linked to the WASP6 model so that the water quality evaluation capabilities of WASP6 could be applied to the simulated real-time stream flows generated by the hydrodynamic model. This linkage allows the assessment of water quality on a real-time basis as well.

The WASP6 model was calibrated initially to data collected in water year 2000. This calibration adequately matched the observed data and was verified with other data sets in 2001. In addition, the model predicted the dissolved oxygen sag minimum around river mile 45, the critical low dissolved oxygen condition, which was later verified by TDEC monitoring. A detailed description of the water quality model and calibration are presented in the TMDL Modeling Report.

Development of the TMDL for the Harpeth River from River Mile 88.1 to River Mile 32.4

The objective of this TMDL is to determine where in the River and under what flow and loading conditions the dissolved oxygen concentrations are most depressed and predict what pollutant load reductions are necessary to achieve the water quality criterion of 5.0 mg/l. Using the calibrated WASP6 model, a continuous simulation was run for the dissolved oxygen profile in the River for the years 2000 and 2001. This extensive data output file was evaluated to determine the current critical conditions for the Harpeth River. The time period August 24, 2000, at 4 pm was chosen as an appropriate critical condition because of the severe dissolved oxygen depletion to near 1.0 mg/l at river mile 44, and the stability and duration of this dissolved oxygen sag event. The intent is to identify a critical condition that is not biased by unstable perturbations, which can occur in a dynamic model. This severe dissolved oxygen depletion occurred about 40 miles downstream of the Franklin WWTP discharge indicating that additional sources of pollution are likely contributing to the depletion of the dissolved oxygen in the River.

The principal sources of pollution impacting this section of the Harpeth River are the major NPDES facility, Franklin WWTP described in Table 9, two minor facilities, Lynnwood and Cartwright which are described in Table 8, and the watershed runoff of nutrients and other pollutants principally from the subwatersheds designated 0105 and 0301 depicted in Figure 13 and requiring nutrient load reductions documented in Table 17. A variety of pollutant load scenarios were investigated and the scenarios used to develop the TMDL are presented below in Figures 16 and 17.

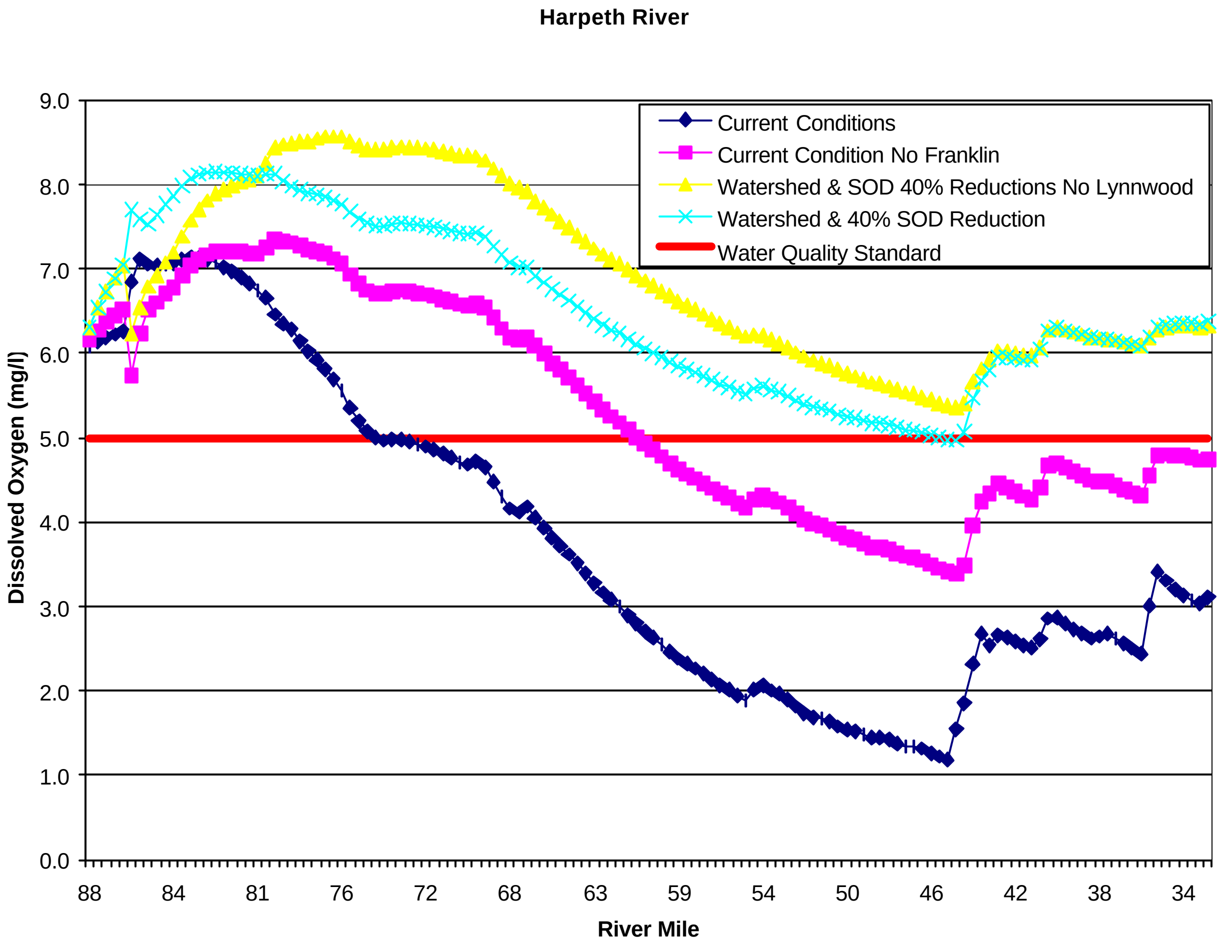

Figure 16 Predicted DO levels versus Pollutant Reduction Scenarios at Critical Conditions

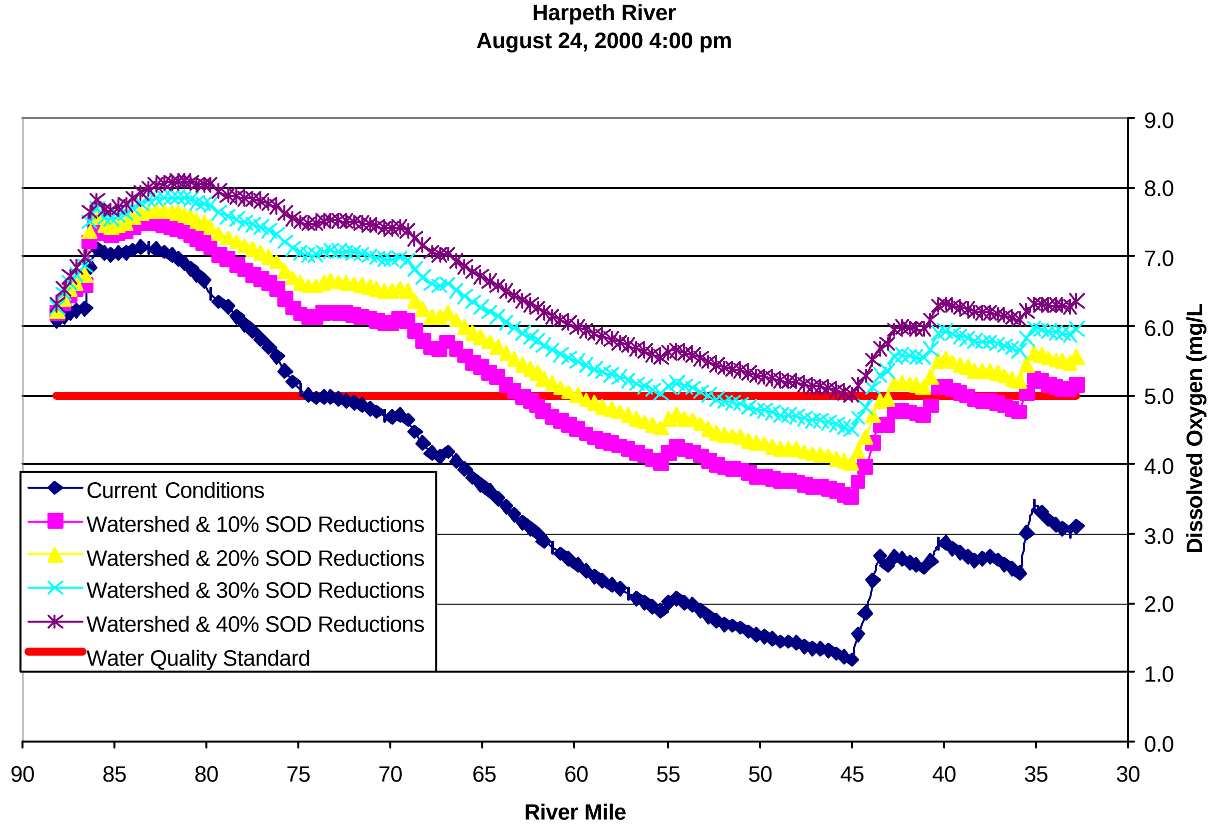

Figure 17 Predicted DO levels versus SOD Reductions at Critical Conditions

As can be seen in Figure 16, removal of the Franklin WWTP discharge improves water quality but does not provide sufficient pollutant load reduction to achieve the water quality criterion of 5.0 mg/l. An SOD reduction of 40 percent will achieve the water quality criterion. An additional scenario, removing the largest minor discharger, Lynnwood WWTP, along with a 40 percent SOD reduction illustrates that the relative impact of this facility and by analogy, Cartwright WWTP, are not sources requiring additional controls to achieve water quality standards.

The sensitivity of the Harpeth River to SOD reductions is illustrated in Figure 17. A 10 percent reduction achieves the greatest incremental improvement in water quality but it does take the 40 percent reduction to fully achieve water quality standards under these critical conditions. It is interesting to note that the removal of the Franklin WWTP discharge is roughly equilavent to a 10 percent reduction in SOD. As disdussed in the headwaters of the Harpeth River section, there is a relationship between the control of polluted runoff from a watershed and the expected relative reduction in the SOD in the receiving stream. EPA believes that there is a reasonable expectation that the nutrient reduction targets for the subwatersheds, especially the border subwatersheds 0105 and 0301 (TN reductions of 44-49% and TP reductions of 82-83%), will require the implementation of best management practice controls sufficient to also achieve a 40 percent reduction in SOD.

At current conditions there does not appear to be a need to require additional controls on the Franklin WWTP since the required pollution load reductions in the border subwatersheds is a greater percentage than the required SOD reduction necessary to achieve water quality standards. However, to fully assess the potential impacts of the Franklin WWTP, the WASP6 model was run with Franklin WWTP operating at its design flow of 12 MGD and CBOD5 permitted concentration of 6 mg/l for the summer monthly average. The WASP6 model used ultimate CBOD to calculate impacts on dissolved oxygen. Two samples of Franklin WWTP discharge were evaluated to determine the ratio of ultimate CBOD to CBOD5. EPA used the most conservative ratio of 5.3, which is significantly greater than the typical range 3-3.5 for advanced secondary WWTPs. The model was run under the critical condition, assuming the 40 percent reduction of SOD is achieved and the Franklin WWTP operating at the design conditions. In addition, the model was run with incremental WWTP load reductions to determine the allowable load under design flow conditions. The results of these model runs are presented in Figure 18.

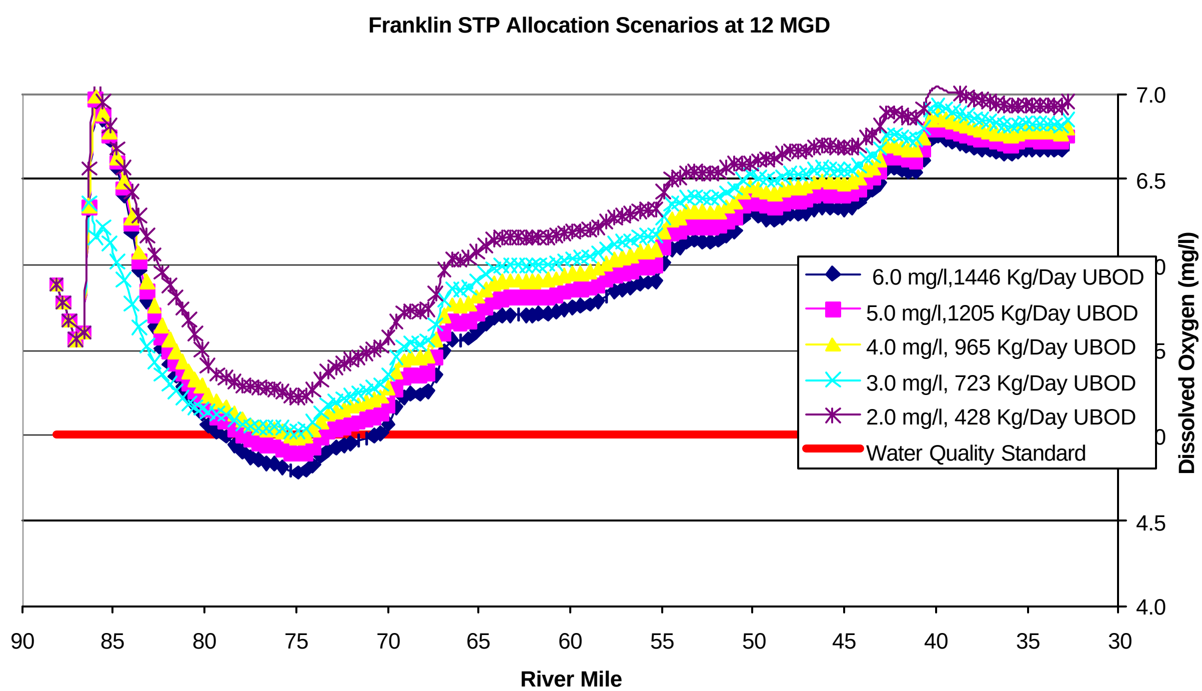

Figure 18 Predicted DO levels versus Franklin WWTP Treatment Levels at Critical Conditions

It is clear that the Franklin WWTP is projected to create a dissolved oxygen deficit about 10 miles downstream of the discharge. The incremental load reduction analysis indicates that the allowable CBOD5 concentration should be 4.0 mg/l calculated using the ultimate CBOD to CBOD5 ratio of 5.3:1. It is interesting to note that even with the existing permit limit of 6 mg/l CBOD5 at the 12 MGD design flow; the dissolved oxygen concentrations actually improve downstream from the projected improvements the 40 % SOD reductions achieve with Franklin WWTP operating at current conditions. This effect can be attributed to the increased flow of about 6 MGD, which is saturated with oxygen to 8.0 mg/l as required under the permit. Under existing conditions, the WWTP was discharging at less than one half of the design flow. The introduction of this significant increased load of oxygen to the stream, over 400 pounds of oxygen per day, plus the improvements in the stream re-aeration characteristics at very low flow conditions account for the significant improvements in the far downstream dissolved oxygen concentrations.

TMDL Allocations for the Harpeth River from River Mile 88.1 to River Mile 32.4

The TMDL is developed to achieve water quality standards under existing conditions as well as ensure that the WWTP design conditions will not violate water quality standards as well. Under existing conditions in the Harpeth River, the extensive dissolved oxygen deficit which begins about river mile 75 and is at its maximum at river mile 45 is the stream use impairment of concern.

As discussed in the previous Section, the only effective means of achieving the 5.0-mg/l water quality criterion is to significantly reduce the SOD in the River. The six subwatershed nutrient TMDLs impacting the lower Harpeth River already require reductions in total nitrogen and phosphorous (median reductions of 44% and 81.3% respectively) which are greater than the 40 percent reduction in SOD necessary to achieve water quality standards. Using the conservative assumption that a percent reduction in watershed pollutant load will achieve a comparable reduction in stream SOD, the implementation of best management practices to address the nutrient controls to protect the tributary streams to the Harpeth River should produce sufficient SOD reduction in the Harpeth River.

As a point of comparison, the daily allowable total nitrogen loads, the limiting nutrient in the Harpeth River, from the six subwatersheds discharging to the lower Harpeth River is 1060 pounds per day (calculated using data in Table 16) and the three WWTPs are projected to discharge 336 pounds per day at design flow conditions (calculated from data in Table10). Since Franklin WWTP contributes 290 pounds of the 336 pounds per day and is 40 miles upstream from the most severe dissolved oxygen deficit, it is reasonable to assume that watershed discharges closer to the impacted zone have a more pronounced impact on SOD. In addition, the three wastewater treatment plants are currently operating close to advanced wastewater treatment performance levels of 4 mg/l CBOD5, 1 mg/l ammonia, and 5 mg/l total nitrogen. These WWTPs are performing at treatment levels, which are technically and economically difficult to surpass. Therefore, EPA considers it appropriate to allocate the allowable total nitrogen load to the lower Harpeth River as a 76% contribution from the watersheds (1060 lbs/day) and a 24% contribution from the WWTPs, (336 lbs/day).

The future condition where Franklin WWTP operates at design flow and pollutant loads and creates a dissolved oxygen deficit ten miles downstream was used to allocate pollutant reductions to the WWTP to ensure water quality standards will be achieved under the current 12 MGD design flow conditions. The load reduction analysis indicates that the allowable CBOD5 concentration should be lowered to 4 mg/l from the current allowable 6 mg/l, based upon the use of the ultimate CBOD to CBOD5 ratio of 5.3:1. A summary of the TMDL load allocations is presented in the Tables below.

Table 25 Wasteload Allocation to WWTPs to protect DO levels in the lower Harpeth River in Critical Summer Conditions

Facility	CBOD5 Lbs/day	Ammonia lbs/day	Total N lbs/day
Franklin	400 (4.0mg/l)	40 (0.4 mg/l)	290 (3.0 mg/l)
Lynnwood	17 (5.0 mg/l)	7 (2.0mg/l)	22 (6.6 mg/l)
Cartwright	10 (5.0 mg/l)	4 (2.0 mg/l)	14 (7.0 mg/l)

Table 26 Wasteload and Load Allocations to Watershed Runoff protect DO levels in the lower Harpeth River in Critical Summer Conditions

HUC-12 Subwatershed (05130204)	Total Nitrogen Summer lbs/month	Total Nitrogen Winter lbs/month	WLA Percent Reduction in MS4 Area	LA Percent Reduction in rural area
0104	7335	12478	20.0	20.0
0105	5864	21966	49.4	49.4
0201	4062	12649	53.1	53.1
0202	3026	9119	53.1	53.1
0301	6253	18537	44.8	44.8
0302	5275	16425	34.3	34.3

Margin of Safety (MOS)

There are two methods for incorporating a MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, an implicit MOS was incorporated through the use of conservative modeling assumptions.

MOS for nutrient TMDLs

The primary conservative assumption was the selection of target concentrations based on the 75th percentile of nutrient data collected from Level IV ecoregion reference sites. These sites represent the least impacted streams in the ecoregion. An explicit MOS of 5% of the TMDL was also utilized prior to calculation of WLAs & LAs (see Appendix I).

MOS for TMDL for Harpeth River Headwaters

The primary conservative assumption was the use of critical low-flow and temperature conditions in the model runs to determine the allocations.

MOS for TMDL for Harpeth River Mile 88.1 to River Mile 32.4

The use of calibrated dynamic models allowed EPA to identify critical flow and pollutant loading conditions that had the most severe impacts on the dissolved oxygen concentration in the River both in terms of magnitude and duration. In addition, there are two controlling conditions: 1) SOD impacts under current loads from the Franklin WWTP and 2) the impacts of the Franklin WWTP at design flow with SOD reduced by 40 percent. When both these conditions are mitigated by pollutant load reductions, the projected dissolved oxygen concentrations exceed 6.0 mg/l where the River now experiences low flow dissolved oxygen levels near 1.0 mg/l.

Seasonal Variation

These TMDLs were developed and designed to provide for year-round protection of water quality and therefore sufficiently address seasonal variations in environmental conditions.

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APPENDIX A

Nutrients & Water Quality

Nutrients and Water Quality

The following information was excerpted from *Protocol for Developing Nutrient TMDLs, First Edition* (USEPA, 1999). Minor formatting changes and the identification of the table have been made for inclusion in this TMDL document. References cited have been included on the last page of this Appendix.

Impact of Nutrients on Designated Uses

Excess nutrients in a waterbody can have many detrimental effects on designated or existing uses, including drinking water supply, recreational use, aquatic life use, and fishery use. For example, drinking water supplies can be impaired by nitrogen when nitrate concentrations exceed 10 mg/L and can cause methemoglobinemia (Blue Baby Syndrome) in infants. Water supplies containing more than 100 mg/L of nitrate can also taste bitter and can cause physiological distress (Straub, 1989).

Although these are examples of the direct impacts that can be associated with excessive nutrient loadings, waters more often are listed as impaired by nutrients because of their role in accelerating eutrophication. Eutrophication, or the nutrient enrichment of aquatic systems, is a natural aging process of a waterbody that transforms a lake into a swamp and ultimately into a field or forest. (The term *eutrophication* as used in this document refers to the nutrient enrichment of both lakes and rivers, although it is recognized that rivers do not have the same natural aging process.) This aging process can accelerate with excessive nutrient inputs because of the impact they have without other limiting factors, such as light.

A eutrophic system typically contains an undesirable abundance of plant growth, particularly phytoplankton, periphyton, and macrophytes. Phytoplankton, photosynthetic microscopic organisms (algae), exist as individual cells or grouped together as clumps or filamentous mats. Periphyton is the assemblage of organisms that grow on underwater surfaces. It is commonly dominated by algae but also can include bacteria, yeasts, molds, protozoa, and other colony forming organisms. The term macrophyte refers to any larger than microscopic plant life in aquatic systems. Macrophytes may be vascular plants rooted in the sediment, such as pond weeds or cattails, or free-floating plant life, such as duckweed or coontail.

The eutrophication process can impair the designated uses of waterbodies as follows:

- *Aquatic life and fisheries.* A variety of impairments can result from the excessive plant growth associated with nutrient loadings. These impairments result primarily when dead plant matter settles to the bottom of a waterbody, stimulating microbial breakdown processes that require oxygen. Eventually, oxygen in the hypolimnion of lakes and reservoirs can be depleted, which can change the benthic community structure from aerobic to anaerobic organisms. Oxygen depletion also might occur nightly throughout the waterbody because of plant respiration. Extreme oxygen depletion can stress or eliminate desirable aquatic life and nutrients, and toxins also might be released from sediments when dissolved oxygen and pH are lowered (Brick and Moore, 1996).

Breakdown of dead organic matter in water also can produce un-ionized ammonia, which can adversely affect aquatic life. The fraction of ammonia present as un-ionized ammonia depends on temperature and pH. Fish may suffer a reduction in hatching success, reductions in growth rate and morphological development, and injury to gill tissue, liver, and kidneys. At certain ammonia levels fish also might suffer a loss of equilibrium, hyperexcitability, increased respiratory activity and oxygen uptake, and increased heart rate. At extreme ammonia levels, fish may experience convulsions, coma, and death (USEPA, 1986a; revised 1998b).

- *Drinking water supply.* Diatoms and filamentous algae can clog water treatment plant filters and reduce the time between backwashings (the process of reversing water flow through the water filter to remove debris). Disinfection of water supplies impaired by algal growth also might result in water that contains potentially carcinogenic disinfection byproducts, such as trihalomethanes. An increased rate of production and breakdown of plant matter also can adversely affect the taste and odor of the drinking water.

- *Recreational use.* The excessive plant growth in a eutrophic waterbody can affect recreational water use. Extensive growth of rooted macrophytes, periphyton, and mats of living and dead plant material can interfere with swimming, boating, and fishing activities, while the appearance of and odors emitted by decaying plant matter impair aesthetic uses of the waterbody.

Nutrient Sources and Transport

Both nitrogen and phosphorus reach surface waters at an elevated rate as a result of human activities. Phosphorus, because of its tendency to sorb to soil particles and organic matter, is primarily transported in surface runoff with eroded sediments. Inorganic nitrogen, on the other hand, does not sorb as strongly and can be transported in both particulate and dissolved phases in surface runoff. Dissolved inorganic nitrogen also can be transported through the unsaturated zone (interflow) and ground water. Because nitrogen has a gaseous phase, it can be transported to surface water via atmospheric deposition. Phosphorus associated with fine-grained particulate matter also exists in the atmosphere. This sorbed phosphorus can enter natural waters by both dry fallout and rainfall. Finally, nutrients can be directly discharged to a waterbody via outfalls for wastewater treatment plants and combined sewer overflows. Table A-1 presents common point and nonpoint sources of nitrogen and phosphorus and the approximate associated concentrations.

Table A-1. Sources And Concentrations Of Nutrients from Common Point and Nonpoint Sources

Source	Nitrogen (mg/l)	Phosphorus (mg/l)

Urban Runoff	3-10	0.2 – 1.7
Livestock operations	6 – 800 [a]	4 – 5
Atmosphere (wet deposition)	0.9	0.015 [b]
Untreated wastewater	35	10
Treated wastewater (secondary treatment)	30	10

a As organic nitrogen; b Sorbed to airborne particulate

Source: Novotny and Olem, 1994

Once in the waterbody, nitrogen and phosphorus act differently. Because inorganic forms of nitrogen do not sorb strongly to particulate matter, they are more easily returned to the water. Phosphorus, on the other hand, can sorb to sediments in the water column and on the substrate and become unavailable. In lakes and reservoirs, continuous accumulation of sediment can leave some phosphorus too deep within the substrate to be reintroduced to the water column, if left undisturbed; however, a portion of the phosphorus in the substrate might be reintroduced to the water column. The activities of benthic invertebrates and changes in water chemistry (such as the reducing conditions of bottom waters and sediments often experienced during the summer months in a lake) also can cause phosphorus to desorb from sediment. A large, slow-moving river also might experience similar phosphorus releases. The sudden availability of phosphorus in the water column can stimulate algal growth. Because of this phenomenon, a reduction in phosphorus loading might not effectively reduce algal blooms for many years (Maki et al., 1983).

Nutrient Cycling

The transport of nutrients from their sources to the waterbody of concern is governed by several chemical, physical, and biological processes, which together compose the nitrogen or phosphorus cycle. Nutrient cycles are important to understand for developing a TMDL because of the information they provide about nutrient availability and the associated impact on plant growth.

Nitrogen

Nitrogen is plentiful in the environment. Almost 80 percent of the atmosphere by volume consists of nitrogen gas (N_2). Although largely available in the atmosphere, N_2 must be converted to other forms, such as nitrate (NO_3^-), before most plants and animals can use it. Conversion into usable forms, both in the terrestrial and aquatic environments, occurs through the four processes of the nitrogen cycle. Three of the processes—nitrogen fixation, ammonification, and nitrification—convert gaseous nitrogen into usable chemical forms. The fourth process, denitrification, converts fixed nitrogen back to the gaseous N_2 state.

- *Nitrogen fixation.* The conversion of gaseous nitrogen into ammonia ions (NH3 and $NH4^+$). Nitrogen-fixing organisms, such as blue-green algae (cyanobacteria) and the bacteria *Rhizobium* and *Azobacter*, split molecular nitrogen (N2) into two free nitrogen molecules. The nitrogen molecules combine with hydrogen molecules to yield ammonia ions.

- *Ammonification.* A one-way reaction in which decomposer organisms break down wastes and nonliving organic tissues to amino acids, which are then oxidized to carbon dioxide, water, and ammonia ions. Ammonia is then available for absorption by plant matter.

- *Nitrification.* A two-step process by which ammonia ions are oxidized to nitrite and nitrate, yielding energy for decomposer organisms. Two groups of microorganisms are involved in the nitrification process. First, *Nitrosomonas* oxidizes ammonia ions to nitrite and water. Second, *Nitrobacter* oxidizes the nitrite ions to nitrate, which is then available for absorption by plant matter.

- *Denitrification.* The process by which nitrates are reduced to gaseous nitrogen by facultative anaerobes. Facultative anaerobes, such as fungi, can flourish in anoxic conditions because they break down oxygen containing compounds (e.g., $NO3^-$) to obtain oxygen.

Once introduced into the aquatic environment, nitrogen can exist in several forms—dissolved nitrogen gas (N2), ammonia ($NH4^+$ and NH3), nitrite ($NO2^-$), nitrate ($NO3^-$), and organic nitrogen as proteinaceous matter or in dissolved or particulate phases. The most important forms of nitrogen in terms of their immediate impact on water quality are the readily available ammonia ions, nitrites, and nitrates (dissolved nitrogen). (Note that plants cannot directly use nitrate but must first convert it to ammonium using the enzyme nitrate reductase. Because the ability to do this is ubiquitous, nitrate is considered to be bioavailable.) Particulate and organic nitrogen, because they must be converted to a usable form, are less important in the short term. Total nitrogen (TN) is a measurement of all forms of nitrogen.

Nitrogen continuously cycles in the aquatic environment, although the rate is temperature-controlled and thus very seasonal. Aquatic organisms incorporate available dissolved inorganic nitrogen into proteinaceous matter. Dead organisms decompose, and nitrogen is released as ammonia ions and then converted to nitrite and nitrate, where the process begins again. If a surface water lacks adequate nitrogen, nitrogen-fixing organisms can convert nitrogen from its gaseous phase to ammonia ions.

Phosphorus

Under normal conditions, phosphorus is scarce in the aquatic environment. Unlike nitrogen, phosphorus does not exist as a gas and therefore does not have gas-phase atmospheric inputs to aquatic systems. Rocks and natural phosphate deposits are the main reservoirs of natural phosphorus. Release of these deposits occurs through weathering, leaching, erosion, and mining. Terrestrial phosphorus cycling includes immobilizing inorganic phosphorus into calcium or iron phosphates, incorporating inorganic phosphorus into plants and microorganisms, and breaking down organic phosphorus to inorganic forms by bacteria. Some phosphorus is inevitably transported to aquatic systems by water or wind.

Nutrients and Water Quality

Phosphorus in freshwater and marine systems exists in either an organic or inorganic form.

- *Organic phosphorus*. Organic particulate phosphorus includes living and dead particulate matter, such as plankton and detritus. Organic nonparticulate phosphorus includes dissolved organic phosphorus excreted by organisms and colloidalphosphorus compounds.

- *Inorganic phosphorus*. The soluble inorganic phosphate forms $H2PO4^{-}$, $HPO4^{2-}$, and $PO4^{3}$, known as soluble reactive phosphorus (SRP), are readily available to plants. Some condensed phosphate forms, such as those found in detergents, are inorganic but are not available for plant uptake. Inorganic particulate phosphorus includes phosphorus precipitates, phosphorus adsorbed to particulate, and amorphous phosphorus.

The measurement of all phosphorus forms in a water sample, including all the inorganic and organic particulate and soluble forms mentioned above, is known as total phosphorus (TP). TP does not distinguish between phosphorus currently unavailable to plants (organic and particulate) and that which is available (SRP). SRP is the most important form of phosphorus for supporting algal growth because it can be used directly. However, other fractions are transformed to more bioavailable forms at various rates dependent on microbial action or environmental conditions. In streams with relatively short residence times, it is less likely that the transformation from unavailable to available forms will have time to occur and SRP is the most accurate estimate of biologically available nutrients. In lakes, however, where residence times are longer, TP generally is considered an adequate estimation of bioavailable phosphorus.

Phosphorus undergoes continuous transformations in a freshwater environment. Some phosphorus will sorb to sediments in the water column or substrate and be removed from circulation. Phytoplankton, periphyton, and bacteria assimilate the SRP (usually as orthophosphate) and change it into organic phosphorus. These organisms then may be ingested by detritivores or grazers, which in turn excrete some of the organic phosphorus as SRP. Some previously unavailable forms of phosphorus also convert to SRP. Continuing the cycle, the SRP is rapidly assimilated by plants and microbes.

Human activities have resulted in excessive loading of phosphorus into many freshwater systems. Overloads result in an imbalance of the natural cycling processes. Excess available phosphorus in freshwater systems can result in accelerated plant growth if other nutrients and other potentially limiting factors are available.

Other Limiting Factors

Many natural factors combine to determine rates of plant growth in a waterbody. First of these is whether sufficient phosphorus and nitrogen exist to support plant growth. The absence of one of these nutrients generally will restrict plant growth. In inland waters, typically phosphorus is the limiting nutrient of the two, because blue-green algae can “fix” elemental nitrogen from the water as a nutrient source. In marine waters, either phosphorus or nitrogen can be limiting. Although carbon and trace elements are usually abundant, occasionally they can serve as limiting nutrients. However, even if all necessary nutrients are available, plant production will not necessarily continue unchecked. Many natural factors, including light availability, temperature, flow levels, substrate, grazing, bedrock type and elevation, control the levels of macrophytes, periphyton, and phytoplankton in waters. Effective management of eutrophication in a waterbody may require a simultaneous evaluation of several limiting factors.

- *Light availability*. Shading of the water column inhibits plant growth. Numerous factors can shade waterbodies, including: (1) as plant production increases in the upper water layer, the organisms block the light and prevent it from traveling deeper into the water column; (2) riparian growth along waterbodies provides shade; and (3) particulates in the water column scatter light, decreasing the amount penetrating the water column and available for photosynthesis.

  With seasonally high particulate matter or shading (e.g., in deciduous forests), the high nutrients may cause excessive growth only during certain times of the year: for example, streams where snowmelt is common in the spring. Snowmelt could lead to high levels of suspended particulate matter and low algal biomass. During stable summer flows, however, there will be lower levels of suspended matter and hence higher algal biomass.

- *Temperature*. Temperature affects the rates of photosynthesis and algal growth, and composition of algal species. Depending on the plant, photosynthetic activity increases with temperature until a maximum photosynthetic output is reached, when photosynthesis declines (Smith, 1990). Moreover, algal community species composition in a waterbody often changes with temperature. For example, diatoms most often are the dominant algal species at water temperatures of 20 ° to 25 °C, green algae at 30 ° to 35 °C, and blue-green algae (cyanobacteria) above 35 °C (Dunne and Leopold, 1978; USEPA, 1986b).

- *Water Velocity*. Water movement in large lakes, rivers, and streams influences plant production. Stream velocity has a two-fold effect on periphyton productivity: increasing velocity to a certain level enhances biomass accrual but further increases can result in substantial scouring (Horner et al., 1990). Large lakes and estuaries can experience the scouring action of waves during strong storms (Quinn, 1991). In rivers and streams, frequent disturbance from floods (monthly or more frequently) and associated movement of bed materials can scour algae from the surface rapidly and often enough to prevent attainment of high biomass (Horner et al., 1990). Rapid flows can sweep planktonic algae from a river reach, while low flows may provide an opportunity for proliferation.

- *Substrate*. Macrophytes and periphyton are influenced by the type of substrate available. Macrophytes prefer areas of fine sediment in which to root (Wright and McDonnell, 1986, in Quinn, 1991). Thus, the addition and removal of sediment from a system can influence macrophyte growth. Periphyton, because of its need to attach to objects, grows best on large, rough substrates. A covering of sediment over a rocky substrate decreases periphyton biomass (Welch et al., 1992).

- *Grazing*. Dense populations of algae-consuming grazers can lead to negligible algal biomass, in spite of high levels of nutrients (Steinman, 1996). The existence of a "trophic cascade" (control of algal biomass by community composition of grazers and their predators) has been demonstrated for some streams (e.g., Power, 1990). Managers should realize the potential control of algal biomass by grazers, but they also should be aware that populations of grazers can fluctuate seasonally or unpredictably and fail to control biomass at times. Consideration of grazer populations might explain why some streams with high nutrients have low algal biomass.

- *Bedrock*. The natural effects of bedrock type also might help explain trophic state. Streams draining watersheds with phosphorus-rich rocks (such as rocks of sedimentary or volcanic origin) can be enriched naturally and, therefore, control of algal biomass by nutrient reduction in such systems might be difficult. Review of geologic maps and consultation with a local soil scientist might reveal such problems. Bedrock composition has been related to algal biomass in some systems (Biggs, 1995).

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APPENDIX B

Results of Greenspan CS304 Combination Sensor

Deployment in the Harpeth River

Figure B-1 Diurnal Dissolved Oxygen in the Harpeth River (8/2/02 to 8/11/02)

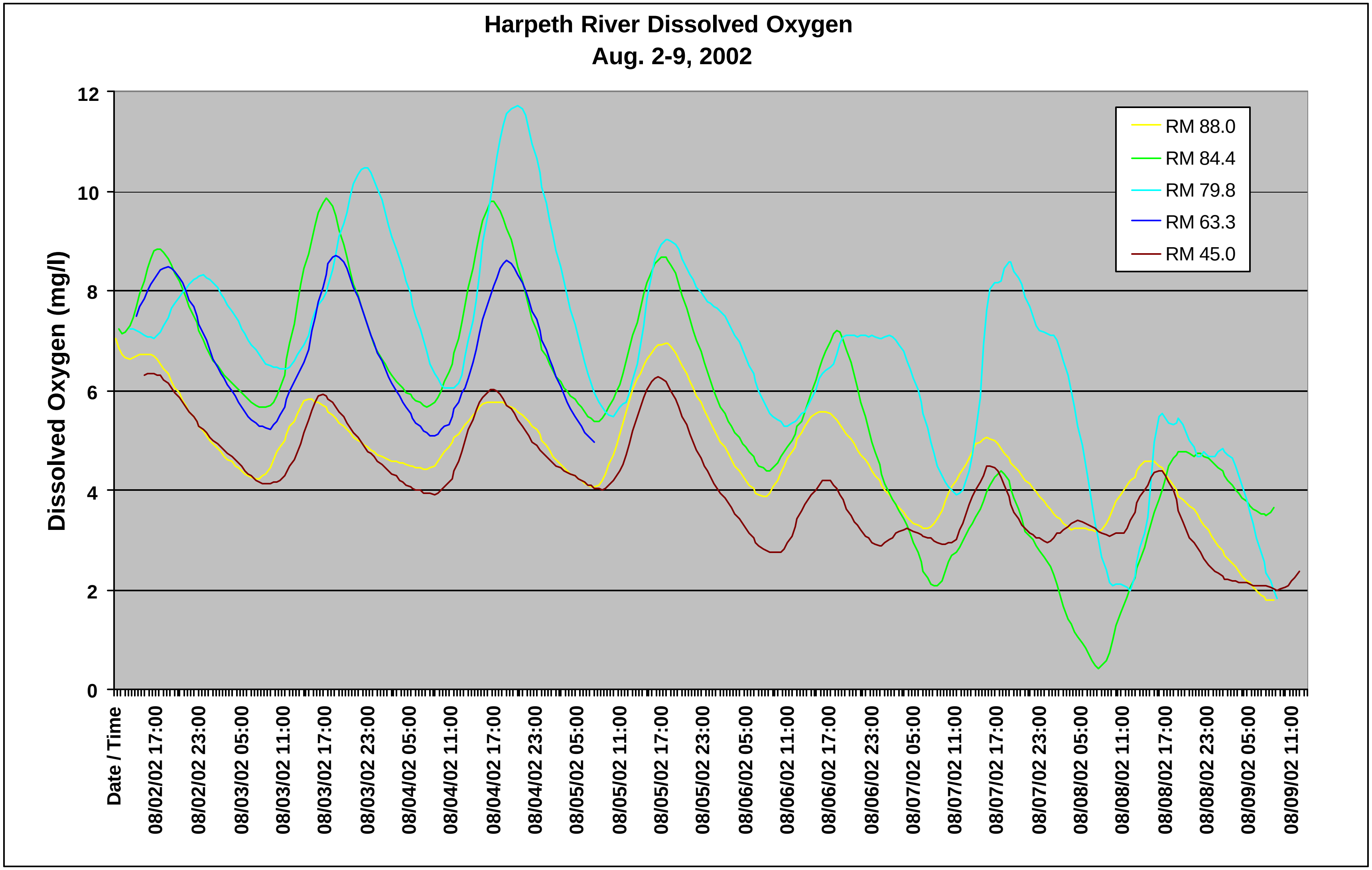


Figure B-2 Harpeth River Temperature (8/2/02 to 8/11/02)

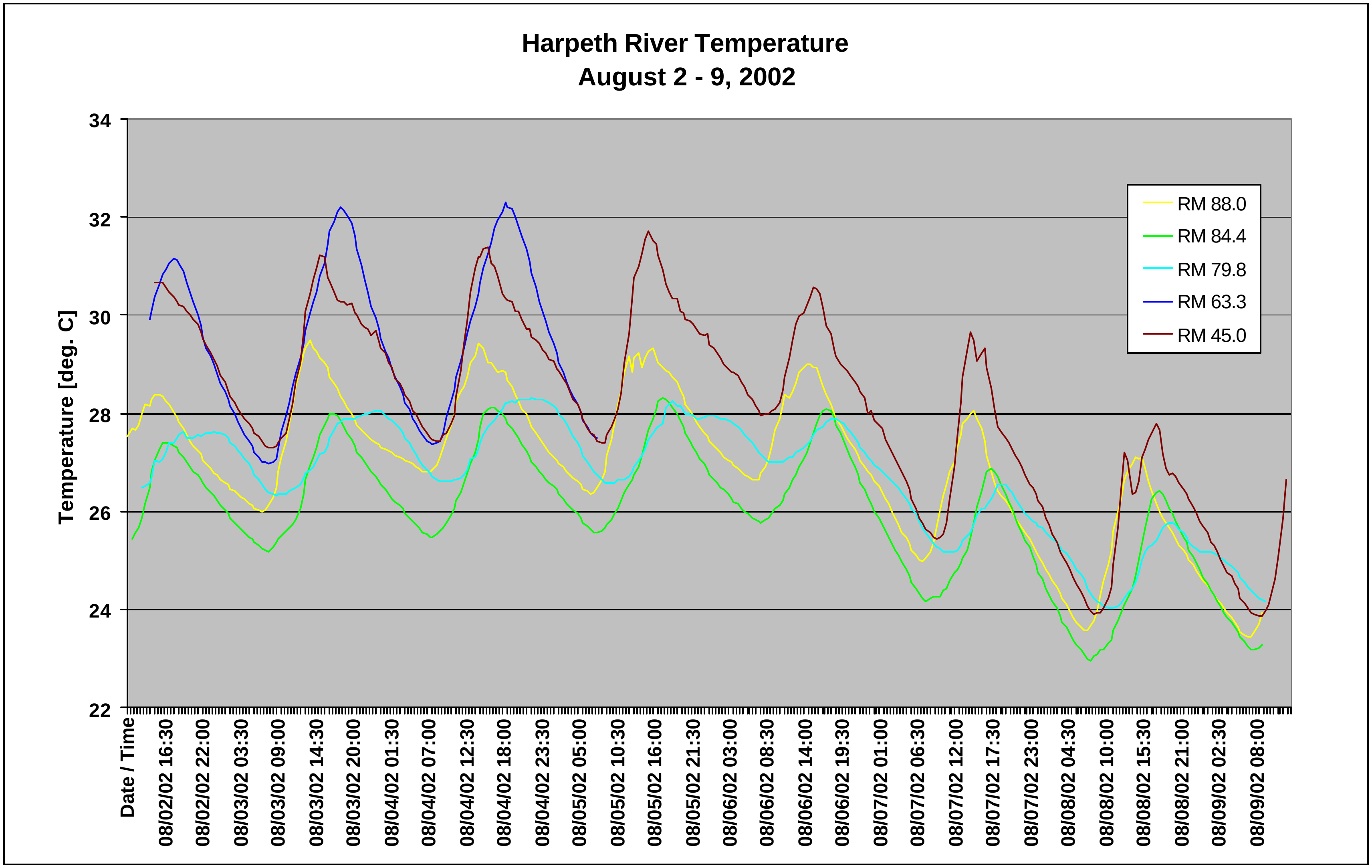


Figure B-3 Harpeth River Conductivity (8/2/02 to 8/11/02)

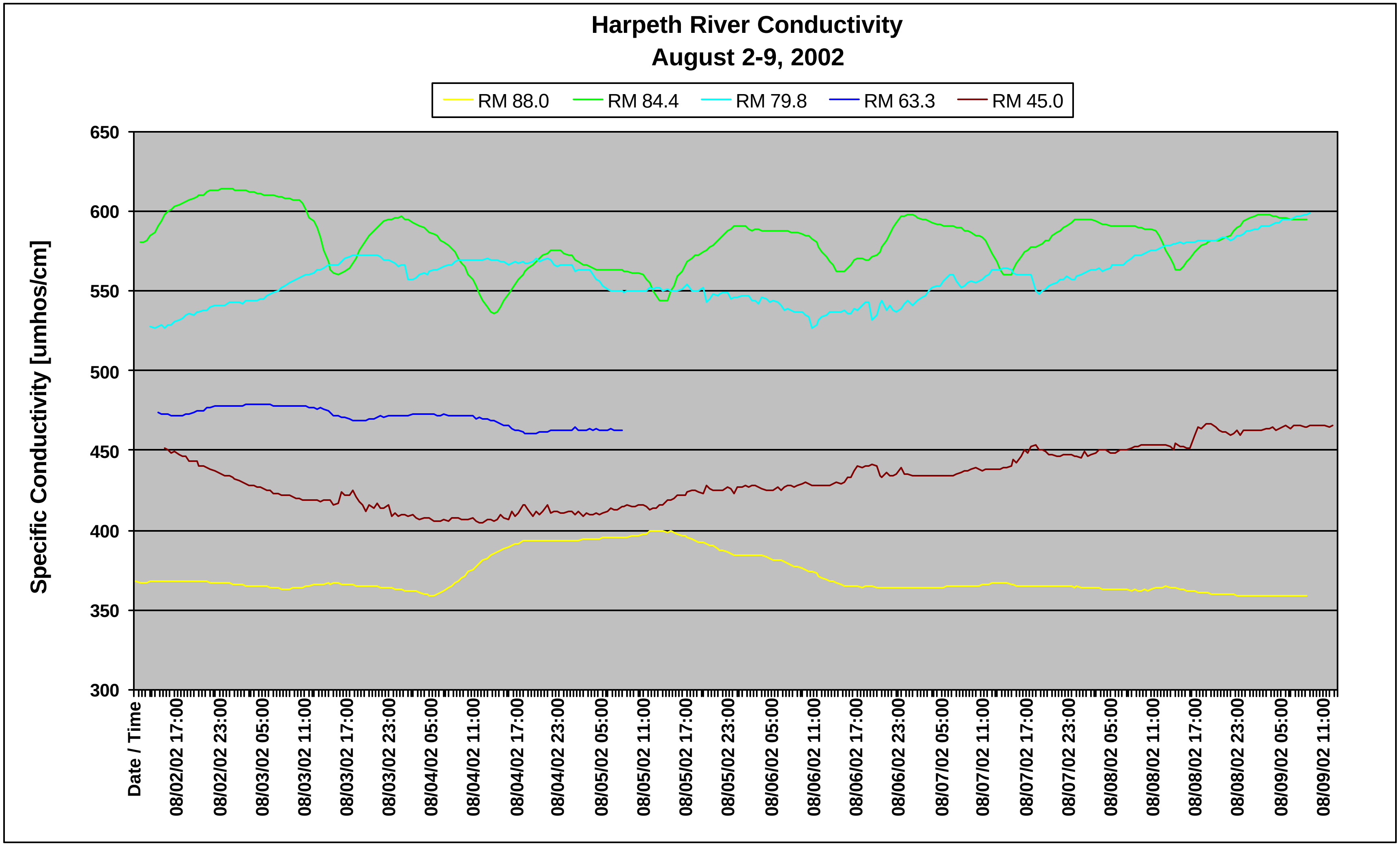


Figure B-4 Diurnal Dissolved Oxygen in the Harpeth River (9/11/02 to 9/25/02)

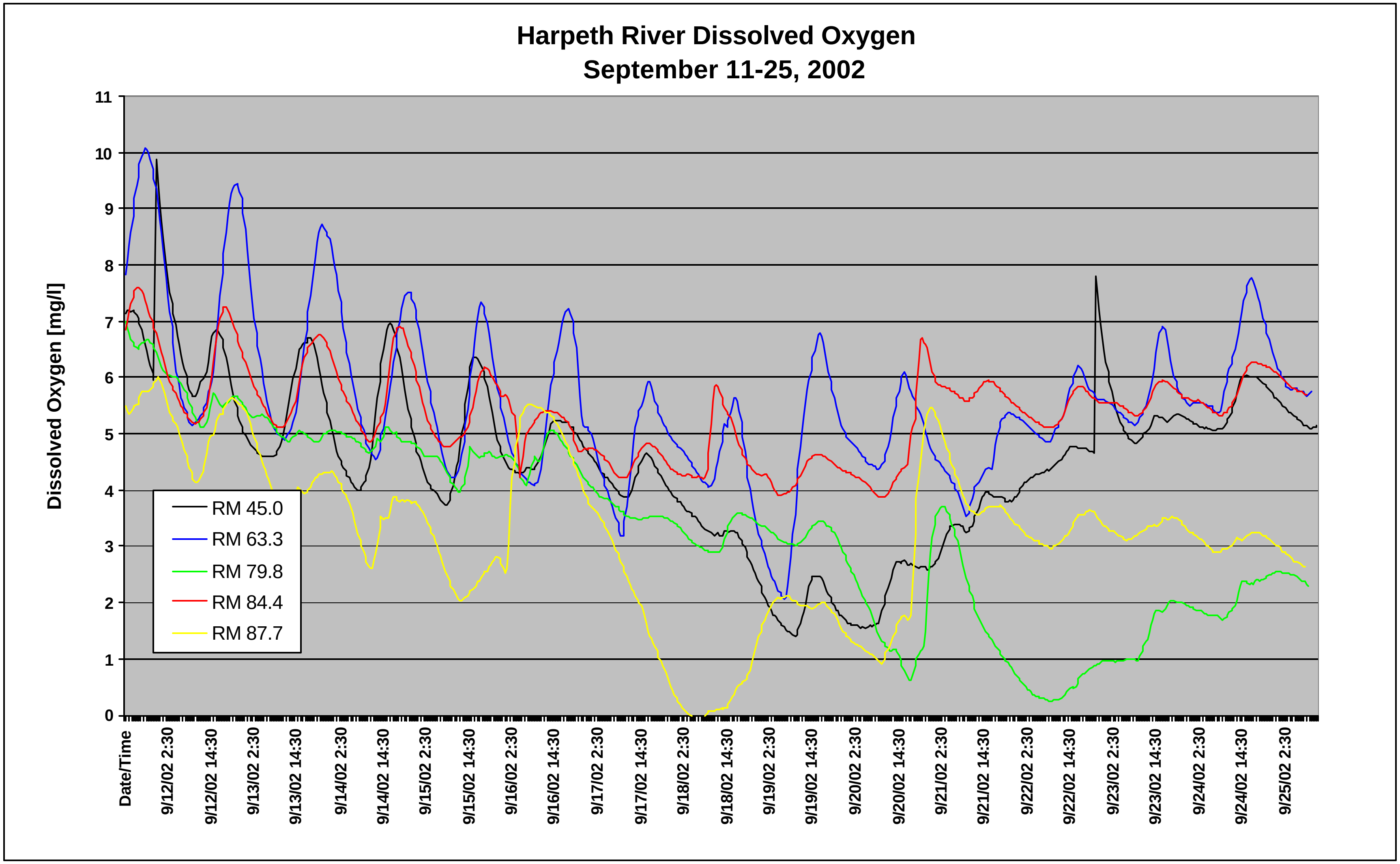
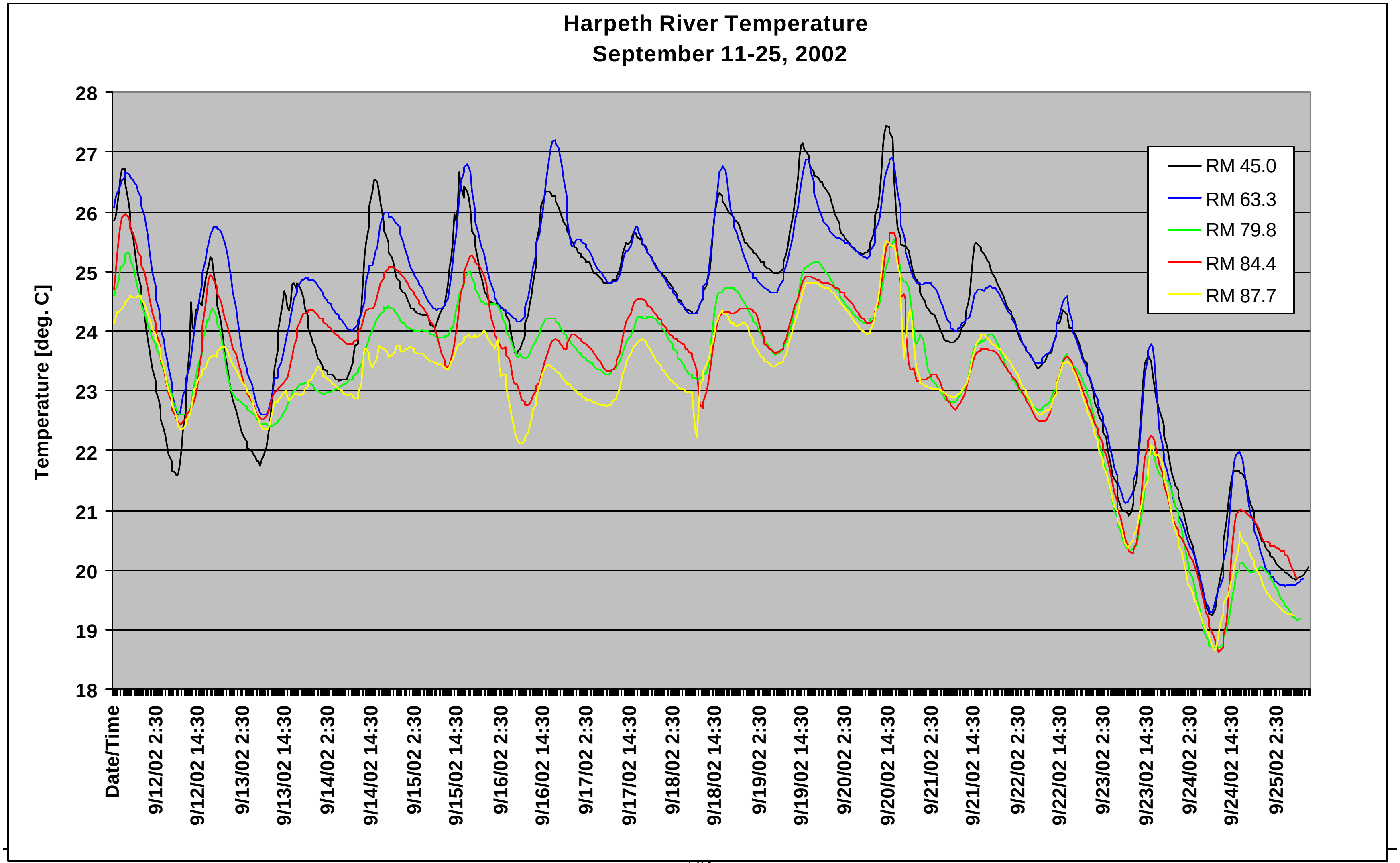


Figure B-5 Harpeth River Temperature (9/11/02 to 9/25/02)



APPENDIX C

Example of Stream Assessment

(Upper Harpeth River)

Example of Stream Assessment – Upper Harpeth River (6 pages)

STREAM; Upper HARpeth River (TN) (WBA Full) STATION #: 5130204 18 6.97=RF3

WBID #: TN05130204016

COUNTY: Rutherford WBID NAME: Upper Harpeth R

NOTE TCW QA/QC + TRAI... see TCW separate sheets

TYPE OF ASSESSMENT: WBA, WWC, RBA, ACAP, General, Observation, Other: WS WBA/RBPI

DRAINAGE BASIN: Lower Cumberland ECOREGION: 71B

POINT (S) OF ASSESSMENT (include RM): RM=116.2 @ SHOEMAKER/RIVER ROAD (used to be Swamp Road) (~1000' ASSESSED) (1:45-3:00)

LAT/LONG FOR EACH POINT: 35° 45' 39" / 86° 37' 39" = GPS

DATE OF ASSESSMENT: 08/06/97 DATE OF REPORT: 08/06+ ASSESSOR: AMG

DRAINS TO: Cumberland R @RM 152.9 -> @RM -> @RM ->

STREAM ORDER: 4th ELEVATION: 720 FT. USGS STA 034320

WATERSHED SIZE: 64.6 mi² 3Q20: 0.0 AT WHAT RM AND/OR LAT/LONG AND SOURCE: RM 102.2 [35° 49' 14" / 86° 41' 16"]

QUADRANGLE # AND NAME: 70SW College Grove, TN MAP ATTACHED? YES NO

GEOLOGIC FORMATION:

TOTAL LENGTH OF STREAM ASSESSED: 1000' assessed

WHAT % OF THE STREAM'S WATERSHED DID YOU OBSERVE, DESCRIBE IT: ~90% of US WS ~~...~~ seen: 80% pasture cows / 20% roads, residents / riparian loss = extensive

PREVIOUS 7-DAY PRECIP: flash flooding, heavy downpour, mod. rainfall, light rainfall, none, don't know

CHANNEL FLOW STATUS: water fills 98-100% of the available channel / 0-2 % of channel substrate exposed

PRESENT AIR TEMP: ~ 89°F WEATHER: sunny, clear

REASON YOU'RE THERE: WATER SHED Screening

LIFE ASSESSED? YES, NO BUGS AND/OR FISH (circle) COLLECTED? YES, NO BUGS AND/OR FISH

LIST TYPE AND LOG NUMBER OF SAMPLES WS Screening

METHOD OF SAMPLING? No riffle in this area, pooled backed up, slow moving water = rock turn + grass Roots

LIST WHAT WAS SEEN AND INDICATE RELATIVE ABUNDANCE OR CIRCLE IF: ~~LIST IS ATTACHED~~

DOMINANT (> AND = 50):

VERY ABUNDANT (30-49):

ABUNDANT (10-29): Beetles - Haliplidae

COMMON (3-9): Baetidae, damselfly

RARE (<3): Snails

grass beds (~3 sweeps)

CHEMICAL SAMPLES TAKEN? YES NO RESULTS ATTACHED? YES NO

pH (s.u.) 6.89 DISS OXYGEN (ppm) 5.6 / 5.55 = YSI #3 (meter)

CONDUCTIVITY (µmhos) 410 TIME

TEMPERATURE 25°C / 24.2 °C OR °F YSI #3 DO meter

METERS USE Hydrolab Surveyor II, Hydrolab Datasonde III, Other: YSI 600/610 = BATT out = Reads not reliable @ this time

SIZE OF STREAM (circle one): very sm.=<5'wide small 5'-10' med.= 10'-30'wide lg.=30'-80' very large=>80'

STREAM SUBSTRATE TYPE (%): flatrock 50, boulder 5, cobble 5, gravel 5, fines (silt 35) (sand)

% CANOPY COVER (circle one): 80-100% 50-75% <50%

FILAMENTOUS ALGAE PRESENT? excessive, moderate, some, none

SEDIMENT PRESENT? excessive, moderate, some, none

WATER APPEARANCE (circle those that apply): clear, slightly turbid, mod. turbid, turbid, opaque, oil sheen

CAUSE: 1600 (H), 1100 (M), 0900 (M) — Source: 1410 (H), 7600 (H), 7000 (M)

PHOTOS TAKEN?: YES NO NUMBER OF PHOTOS: 2 (#5 4/5, #6 4/5)

IMPACTS: (circle and rate, with 5 most severe, those that apply):

PERMITTED DISCHARGE	1 2 3 4 5	INDUSTRIAL STORMWATER	1 2 3 4 5	BYPASS	1 2 3 4 5
SPILL/ILLEGAL DISCHARGE	1 2 3 4 5	WATER INTAKE	1 2 3 4 5	URBAN STORMWATER	1 2 3 4 5
SOIL FROM CONSTRUCTION	1 2 3 4 5	SOIL EROSION - AGRICULTURE	1 2 3 4 5	LIVESTOCK	1 2 3 4/5
PEST/HERB RUNOFF	1 2 3 4 5	DAM	1 2 3 4 5	STREAM ALTERATION	1 2 3 4 5
SEVERE BANK EROSION	1 2 3 4 5	RESIDENTIAL IMPACTS	1 2 3 4 5	RIPARIAN LOSS	1 2 3 4 5
LANDFILL 1 2 3 4 5	MINING	1 2 3 4 5	LOGGING	1 2 3 4 5	UNKNOWN 1 2 3 4 5
OTHER:			OTHER:		

RATE THE FOLLOWING USE CLASSIFICATIONS (S),(T), (PS), (NS):

NS FISH & AQUATIC LIFE ____ IRRIGATION ____ RECREATION ____ LW AND W

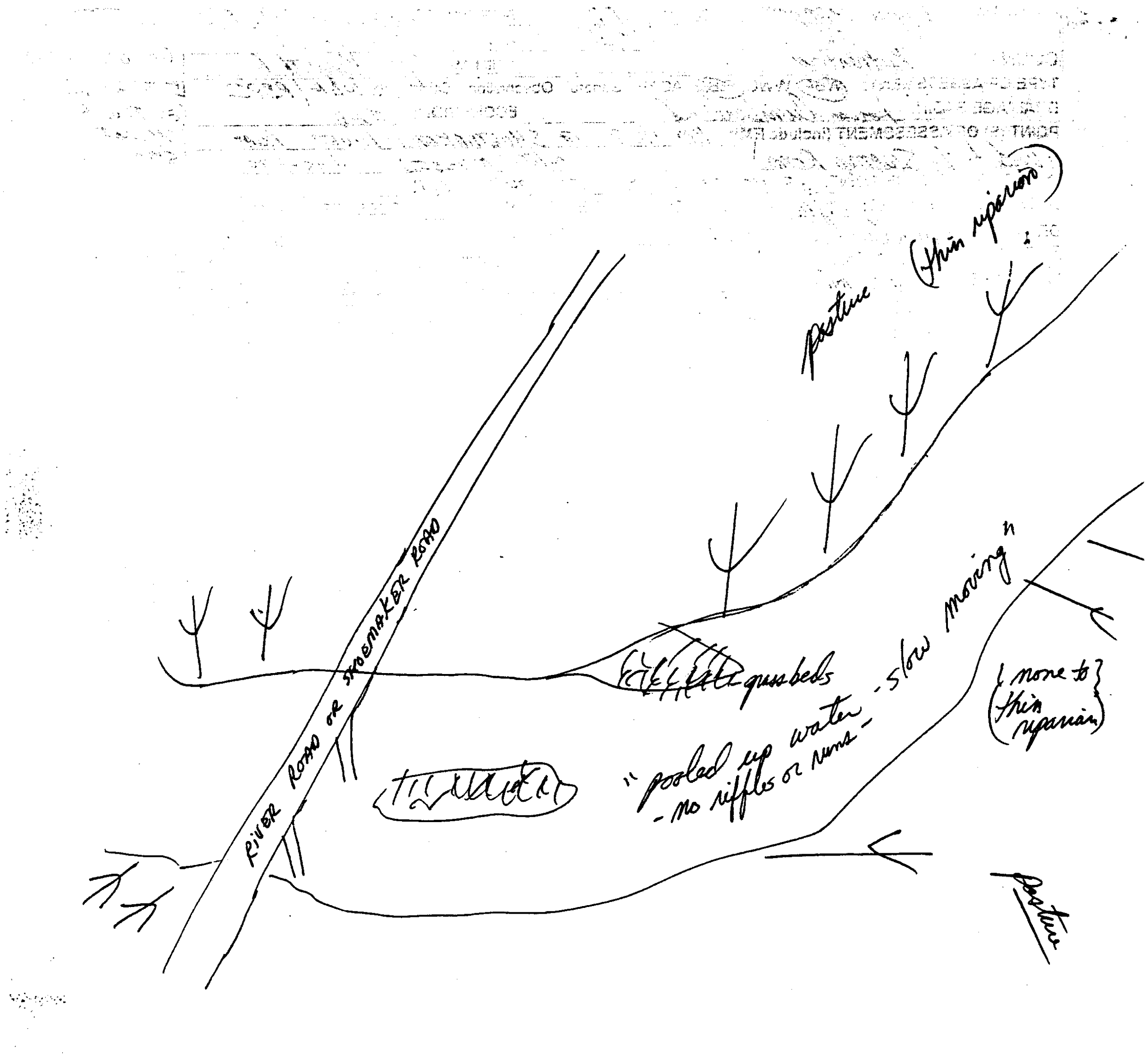
BASED ON WHAT YOU OBSERVED OR MEASURED WOULD YOU CONSIDER THIS STREAM OVERALL (circle one): SUPPORTING (S), THREATENED (T)*, PARTIALLY SUPPORTING (PS), NONSUPPORTING (NS)

*A"T"status designates an immediate threat to the stream, indicating within a two year period or less the stream status may degrade to"PS".

EXPLAIN THE REASONS FOR YOUR ASSESSMENT, IF AN IMPACT FULLY EXPLAIN THE CAUSE AND TYPE OF IMPACT

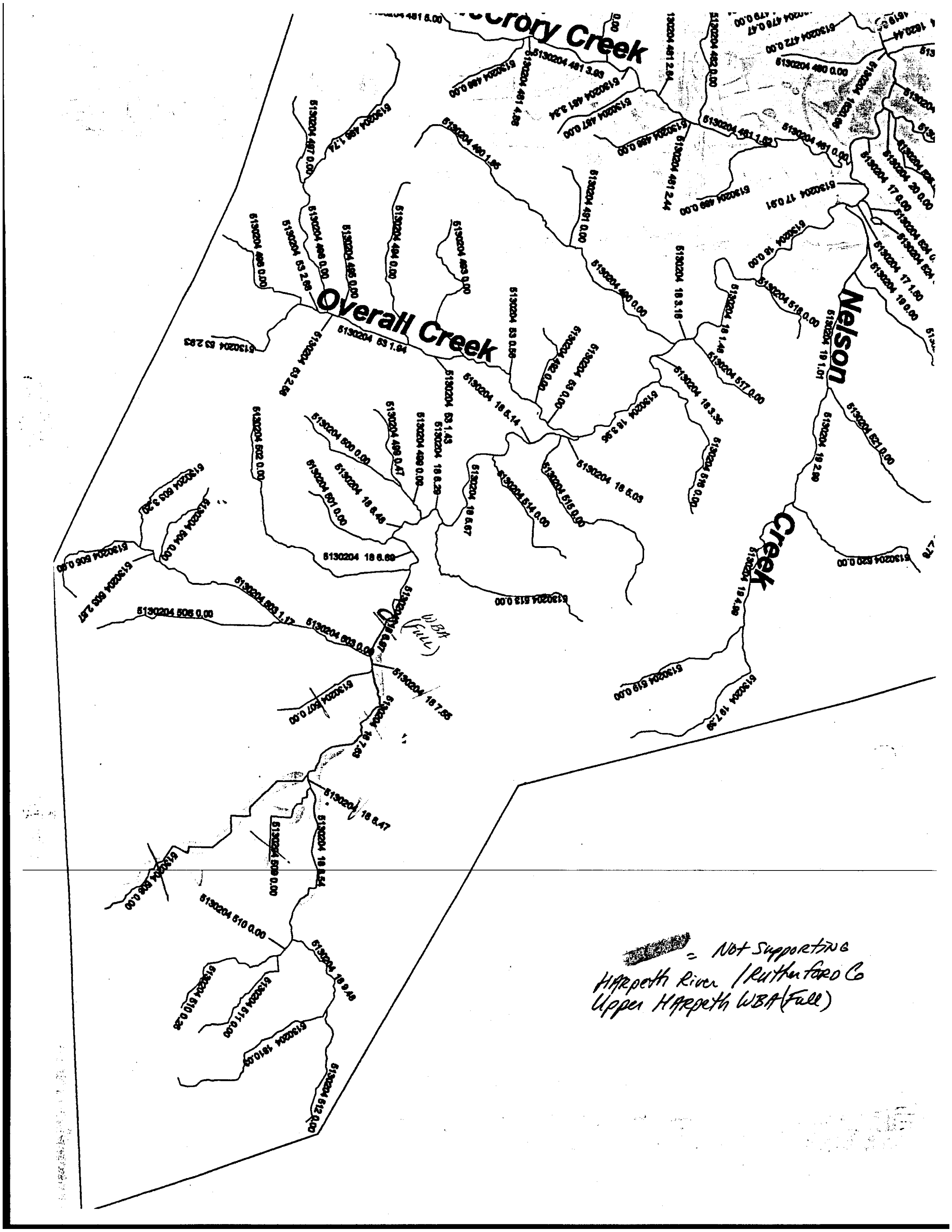
Macroinvertebrates were scarce on rocks - a grass roots net sweep (~3 sweeps) revealed few Macroinvertebrates - @ this time this appears to represent an overall "NS" status - fish were noted - quite numerous - extensive riparian loss - pasture cows

Habitat Score= 92



	Riffle	Run	Pool
L =	–	–	–
W =	–	–	–
D =	–	–	–


Taylor Cem
Concord
Puckett
Branch
Puckett Store
Hudson Cem
Bett
BM 75-42-6
742
ROAD
BM
741
Cem
E O ROCK RD
River
SWAMP
Scott Cem
Bennett Cem
Cem
Mt Vernon
Mt Vernon Ch
Head of River Spring
BM 75-42-10
Harpeth
Creek
Cheatham
Branch
Eagleville
Kelley
Kelley Cem
Owen Cem
Hayes Cem
King Cem
70 SW College GROVE / 70 SE Rock VALE
71 NW CHAPEL HILL / 71 NE ROVER (TN)
Upper HArpeth WBA (Full) (Rutherf.Co)


Overall Creek
Nelson Creek
Crory Creek
5130204 63 1.94
= Not Supporting
Harpeth River / Rutherford Co
Upper Harpeth WBA (Fall)

HABITAT ASSESSMENT FIELD DATA SHEET TN 05130204016 Upper Harpeth WBA (Full) RIFFLE/RUN PREVALENT STREAMS

STREAM Upper Harpeth River DATE Wed 08/06/97

SITE @ Shoemaker / River Rd INVESTIGATOR AMC = (92) (~1000 - feet assessed)

Riffle/Run Prevalent Streams are those in moderate to high gradient landscapes that sustain water velocities of approximately 1 ft/sec or greater. Natural streams have substrates primarily composed of coarse sediment particles (i.e., gravel or larger) or frequent coarse particulate aggregations along stream reaches.

Habitat Parameter	Category: Optimal	Suboptimal	Marginal	Poor
1. Instream Cover (Fish)	Greater than 50% mix of snags, submerged logs, undercut banks, or other stable habitat.	30-50% mix of stable habitat; adequate habitat for maintenance of populations.	10-30% mix of stable habitat; habitat availability less than desirable.	Less than 10% mix of stable habitat; lack of habitat is obvious.
SCORE 15.5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Epifaunal Substrate no riffles in this area; still pooled standing water	Well-developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble.	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; gravel or large boulders and bedrock prevalent; some cobble present.	Riffles or runs virtually nonexistent; large boulders and bedrock prevalent; cobble lacking.
SCORE 5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 6.5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	New embankments present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted.
SCORE 13	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from coarse gravel; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, coarse sand on old and new bars; 30-50% of the bottom affected; sediment deposits at obstruction, constriction, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

(92) = Even near headwaters of Upper Harpeth River = cattle, no riparian, silted water

Barbour and Stribling, Visual-Based Habitat Assessment, Figure 10

RIFFLE/RUN PREVALENT STREAMS

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
6. Frequency of Riffles not sure on this parameter	Occurrence of riffles relatively frequent; distance between riffles divided by the width of the stream equals 5 to 7; variety of habitat is key. In the highest gradient streams (e.g., headwaters), riffles are continuous, and placement of boulders or other large, natural obstruction is evaluated as providing habitat diversity.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream equals 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is between ratio >25.
SCORE 5(?)	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Flow Status	Water reaches base of both lower banks and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 19	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption, through grazing or mowing, minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.
SCORE 3 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 3 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. < 5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 6 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 6 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE 1 (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score 92

Barbour and Stribling, Visual-Based Habitat Assessment, Figure 10, p. 2

APPENDIX D

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for organic enrichment/low dissolved oxygen or nutrients in the Harpeth River watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded at these stations for organic enrichment/low dissolved oxygen or nutrient parameters since 1/1/93 are tabulated in Table D-1.

Table D-1 Water Quality Monitoring Data – Harpeth River Watershed

Monitoring Station	Date	NH_3 (as N) [mg/l]	TKN [mg/l]	DO [mg/l]	NO_3+NO_2 [mg/l]	Total Phosphorus [mg/l]	Temp [°C]	Flow [cfs]
ARKAN000.1WI	10/10/01	<0.02	<0.10	10.1	0.03	0.068	14.4	1.82
	11/29/01	0.02	0.38	9.7	0.17	0.604	14.0	
	12/15/01	<0.02	0.11	12.0	0.20	0.28	10.4	
	12/18/01	<0.02	0.18	12.0	0.10	0.050	10.4	6.95
	1/22/02	<0.02	<0.10	15.3	0.11	0.033	3.7	
	2/26/02	<0.02	<0.10	14.0	0.10	0.01	5.8	8.19
	3/26/02	<0.02	0.12	11.4	0.64	0.05	11.6	
	4/5/02	<0.02	<0.10	11.1	0.04	<0.004	12.6	7.47
	4/8/02	<0.02	<0.10		0.04	<0.004		
	5/6/02	<0.02	<0.10		0.03	<0.004	16.1	9.14
	6/25/02	0.04	0.12	11.5	0.26	0.247	20.4	
CHEAT000.1RU	10/9/01	<0.02	<0.10	9.4	0.64	<0.004	15.5	0.08
	11/8/01	0.06	0.14	12.7	0.19	0.071	14.1	0.01
	2/21/02	<0.02	<0.10	12.8	0.38	0.15	10.1	1.74
	5/23/02	<0.02	<0.10	9.8	2.32	0.087	14.1	0.16
CONCO001.1RU	10/9/01	<0.02	<0.10	5.7	0.29	<0.004	12.0	0.27
	11/8/01	0.09	<0.10	8.4	0.12	0.057	7.6	0.02
	12/11/01	<0.02	0.11	6.8	0.48	0.023	12.7	
	12/12/01	<0.02	<0.10	7.1	0.47	0.058	12.6	
	1/29/02	<0.02	<0.10	6.9	0.22	0.56	12.7	
	2/21/02	<0.02	<0.10	9.6	0.11	0.01	8.5	0.22

	3/18/02		0.35 [c]	9.4	0.16	0.21 [c]	13.1	
	4/10/02	<0.02	<0.10	9.7	0.04	<0.004	11.8	0.29
	5/23/02	<0.02	<0.10	8.9	0.04	0.011	14.0	0.06
	6/11/02	0.03	0.34	**3.1**	0.20	0.05	20.6	0.01
	7/29/02				0.05	0.167		

Table D-1 Water Quality Monitoring Data – Harpeth River Watershed (Continued)

Monitoring Station	Date	NH_3 (as N)	TKN	DO	NO_3+NO_2	Total Phosphorus	Temp	Flow
		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[°C]	[cfs]
ECO71I15	1/24/00	<0.02	<0.10	11.9	1.05	0.17	3.1	49. 9
	5/3/00	<0.02	0.15	10.8	0.55	0.11	19.4	43.7
	7/13/00	0.13	0.22	6.2	0.50	0.16	26.9	0.70
	10/31/00	0.02	1.12	10.1	0.09	0.92	17.7	0.09
	5/9/01	0.03	0.26	9.8	0.42	0.25	20.0	
	10/9/01	<0.02	<0.10	10.4	0.93	0.211	14.7	11.34
	11/8/01	0.08	<0.10	11.5	0.21	0.153	11.3	5.03
	12/12/01	0.09	0.13	10.1	1.11	0.142	12.7	187.5
	1/29/02	0.02	0.13	10.4	0.96	0.190	13.0	
	2/21/02	<0.02	<0.10	12.9	0.26	0.12	11.0	77.3
	3/18/02	<0.02	<0.10 [c]	9.5	0.37	0.39 [c]	13.1	
	4/10/02	<0.02	<0.10	11.2	0.35	0.07	15.7	104.1
	5/23/02	<0.02	<0.10	12.9	0.83	0.131	16.0	
	6/11/02	0.03	0.36	6.6	0.72	0.22	19.4	3.03
FIVEM001.4WI	10/10/01	<0.02	<0.10	10.1	0.97	0.501	17.8	0.84
	11/29/01	0.09	0.47	8.9	0.66	11.8	15.5	
	12/18/01	<0.02	<0.10	10.8	1.98	0.414	13.8	19.1
	1/22/02	<0.02	<0.10	13.6	1.87	0.309	9.4	17.0
	2/28/02	<0.02	<0.10	14.8	1.33	0.33	3.1	7.09
	3/27/02	<0.02	0.18	12.3	1.5	0.33	9.4	21.2
	4/11/02	<0.02	<0.10	15.5	0.97	0.30	13.1	34.2

	5/15/02	<0.02	<0.10	9.2	1.47	0.40	14.7	34.2
	6/4/02	0.11	0.45	12.6	2.18	0.49	21.8	2.09
HARPE079.8WI	10/10/01	<0.02	0.16	7.8	0.74	0.402	17.0	31.54
	11/29/01	0.03	2.20	9.9	0.05	5.69	15.3	
	12/18/01	<0.02	0.10	9.8	1.57	0.271	13.6	310
	1/22/02	<0.02	0.15	12.1	1.35	0.202	8.5	400
	2/28/02	<0.02	<0.10	14.7	0.90	0.20	4.6	295.8
	3/27/02	<0.02	0.41	10.6	1.31	0.28	11.2	970
	4/11/02	<0.02	<0.10	13.3	1.05	0.22	15.9	
	5/15/02	<0.02	<0.10	7.7	1.21	0.39	16.0	
	6/4/02	<0.02	0.19		1.08	0.42	24.3	39.04
	3/19/03		0.41		1.23	0.85		
	4/3/03		<0.10		0.59+	0.2		
HARPE084.4WI	3/19/03		0.29		1.01	1.1		
	4/3/03		<0.10		0.73	0.27		

Table D-1 Water Quality Monitoring Data – Harpeth River Watershed (Continued)

Monitoring Station	Date	NH_3 (as N)	TKN	DO	NO_3+NO_2	BOD_5	Total Phosphorus	Temp	Flow
		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[°C]	[cfs]
HARPETH085.2	6/8/94	<0.02		8.9		<2		21.5	
	5/23/95	<0.02		10.4		<2		18.5	
	6/18/96	<0.02		**9.3**		<2		23.8	
	7/9/97	0.02		7.5		2		19.9	
HARPE087.7DA	3/19/03		0.4		0.76		0.76		
	4/3/03		<0.10		0.38		0.12		
HARPE092.4WI	10/10/01	<0.02	0.11	8.3	0.65		0.404	15.6	16.22
	11/29/01	0.05	0.40	8.7	0.72		3.22	15.3	
	12/18/01	<0.02	0.22	**10.1**	1.36		0.227	12.7	360
	1/22/02	<0.02	0.10	12.1	1.13		0.142	7.5	460
	2/28/02	<0.02	<0.10	14.4	0.49		0.18	2.4	160
	3/27/02	<0.02	0.31	11.2	0.84		0.21	10.3	500
	4/11/02	<0.02	<0.10	11.9	0.43		0.15	15.5	193
	5/15/02	<0.02	<0.10	8.4	1.03		0.34	15.2	
	6/4/02	<0.02	0.12	15.2	0.72		0.28	24.5	24.56
JONES014.4DI	9/10/02				0.19		0.15		
	9/17/02				0.28		0.15		
JONES019.6DI	11/13/01	<0.02	<0.10	16.1	0.62		0.118	12.3	10.3
	12/5/01	<0.02	<0.10	10.6	1.75		0.027	14.7	48.47
	2/19/02	<0.02	0.17 [c]	18.6	0.40 [c]		0.22 [c]	10.1	13.47
	3/27/02	<0.02	<0.10	11.8	0.96		0.34	13.0	

	4/25/02	0.16	0.26	12.9	1.32		0.16	16.7	23.49
	5/14/02	<0.02	<0.10	10.8	0.93		0.10	17.0	56.17
	6/12/02	<0.02	<0.10	11.3	1.24		0.54	25.2	8.08
JONES021.7	6/8/94	<0.02		8.9		<2		21.5	
	5/23/95	<0.02		10.4		<2		18.5	
	6/18/96	<0.02		9.3		<2		23.8	
	7/9/97	0.02		7.5		2		19.9	
RATTL000.2WI	10/2/02				4.80		0.18		
	10/9/02				3.90		0.17		

Table D-1 Water Quality Monitoring Data – Harpeth River Watershed (Continued)

Monitoring Station	Date	NH_3 (as N)	TKN	DO	NO_3+NO_2	Total Phosphorus	Temp	Flow
		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[°C]	[cfs]
KELLE000.4RU	10/9/01	<0.02	<0.10		0.03	<0.004	15.2	2.57
	11/8/01	0.07	<0.10	12.1	0.44	0.187	11.9	0.54
	12/12/01	0.04	0.13	8.6	0.61	0.030	13.2	36.07
	1/29/02	0.02	0.21	8.0	0.15	0.116	11.8	91.57
	2/21/02	<0.02	<0.10	10.7	0.35	0.04	10.6	18.06
	3/18/02	<0.02	<0.10 [c]	9.5	0.17	0.18 [c]	13.0	
	4/10/02	<0.02	<0.10	9.2	0.10	<0.004	16.4	64.52
	5/23/02	<0.02	<0.10	13.3	0.51	0.024	17.2	3.71
	6/11/02	0.03	0.34	6.6	0.61	0.03	23.4	0.54
	7/29/02				0.36	0.056		
	8/6/02				0.23	0.085		
LHARP001.0WI	10/18/01	<0.02	0.11	11.0	1.65	0.367	11.8	14.85
	11/20/01	<0.02	0.18	9.0	0.09	0.250	10.8	1.33
	12/13/01	0.18	0.18	9.6	0.36	0.353	14.9	218.9
	1/23/02	0.06	0.31	10.7	0.95	0.848	10.9	160
	2/28/02	<0.02	<0.10	15.9	1.05	0.18	4.2	29.3
	4/11/02	<0.02	<0.10	18.0	0.77	0.18	16.1	41.28
	5/15/02	<0.02	<0.10	8.34	1.28	0.26	16.4	94.36
	6/4/02	<0.02	0.28		0.85	0.32	24.6	5.5
LHARP001.8WI	10/2/02				1.53	0.15		
	10/9/02				1.27	0.13		

PUCKE000.9RU	10/9/01	<0.02	<0.10	7.0	0.28	<0.004	13.5	0.45
	11/8/01	0.08	<0.10	9.7	0.09	<0.004	9.5	0.01
	12/12/01	0.02	0.17	10.0	0.21	0.12	11.1	2.57
	1/29/02	0.02	0.12	8.7	0.18	0.019	12.4	1.87
	2/21/02	<0.02	<0.10	8.7	0.10	0.02	10.0	1.33
	4/10/02	0.04	<0.10	10.8	0.12	<0.004	15.1	0.42
	5/26/02	<0.02	0.10	8.7	0.19	<0.004	13.7	0.06
WHARP017.7WI	10/10/01	<0.02	<0.10	8.4	0.91	0.394	14.5	1.82
	11/29/01	0.19	0.54	8.1	0.60	3.80	15.3	
	12/18/01	<0.02	0.26	10.4	2.43	0.349	12.9	66.93
	1/22/02	<0.02	<0.10	13.1	2.22	0.244	8.2	23.37
	2/26/02	0.02	0.20	13.6	1.52	0.21	8.1	23.37
	3/26/02	0.04	0.41	10.4	1.8	0.47	13.0	
	4/8/02	<0.02	<0.10	10.8	1.72	0.28	13.7	36.92
	5/6/02	<0.02	0.11	9.3	1.41	0.34	16.2	47.83
	6/25/02	0.03	<0.10	8.5	1.33	0.579	22.1	2.10

Table D-2 Water Quality Monitoring Data – TN/TP Ratio

Monitoring Station	Sample Date	Flow [cfs]	Total Nitrogen [a] [mg/l]	Total Phosphorus [mg/l]	TN/TP
ARKAN000.1WI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	11/29/01		0.55	0.604	0.9
	12/15/01		0.31	0.28	1.1
	12/18/01	6.95	0.28	0.050	5.6
	1/22/02		0.16	0.033	4.8
	2/26/02	8.19	0.15	0.01	15.0
	3/26/02		0.76	0.05	15.2
	4/5/02	7.47	0.09	0.002 [c]	45.0
	4/8/02		0.09	0.002 [c]	45.0
	5/6/02	9.14	0.08	0.002 [c]	40.0
	6/25/02		0.38	0.247	1.5
				Average	15.9
CHEAT000.1RU	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	11/8/01	0.01	0.33	0.071	4.6
	2/21/02	1.74	0.43	0.15	2.9
	5/23/02	0.16	2.37	0.087	27.2
				Geometric Mean	18.8
CONCO001.1RU	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	11/8/01	0.02	0.17	0.057	3.0
	12/11/01		0.59	0.023	25.7
	12/12/01		0.52	0.058	9.0
	1/29/02		0.27	0.56	0.5
	2/21/02	0.22	0.16	0.01	16.0
	3/18/02		0.51	0.21	2.4
	4/10/02	0.29	0.09	0.002 [c]	45.0
	5/23/02	0.06	0.09	0.011	8.2
	6/11/02	0.01	0.54	0.05	10.8
				Average	29.0
FIVEM001.4WI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	11/29/01		1.13	11.8	0.1
	12/18/01	19.1	2.03	0.414	4.9
	1/22/02	17.0	1.92	0.309	6.2
	2/28/02	7.09	1.38	0.33	4.2
	3/27/02	21.2	1.68	0.33	5.1
	4/11/02	34.2	1.02	0.30	3.4
	5/15/02	34.2	1.52	0.40	3.8
	6/4/02	2.09	2.63	0.49	5.4

	Geometric Mean	2.7

Table D-2 Water Quality Monitoring Data – TN/TP Ratio (Continued)

Monitoring Station	Sample Date	Flow [cfs]	Total Nitrogen [a] [mg/l]	Total Phosphorus [mg/l]	TN/TP
ECO71I15	1/24/00	49. 9	1.1	0.17	6.5
	5/3/00	43.7	0.7	0.11	6.4
	7/13/00	0.70	0.72	0.16	4.5
	10/31/00	0.09	1.21	0.92	1.3
	5/9/01		0.68	0.25	2.7
	10/9/01	11.34	0.98	0.211	4.6
	11/8/01	5.03	0.26	0.153	1.7
	12/12/01	187.5	1.24	0.142	8.7
	1/29/02		1.09	0.190	5.7
	2/21/02	77.3	0.31	0.12	2.6
	3/18/02		0.42	0.39	1.1
	4/10/02	104.1	0.4	0.07	5.7
	5/23/02		0.88	0.131	6.7
	6/11/02	3.03	1.08	0.22	4.9
				Average	4.5
HARPE079.8WI	10/10/01	31.54	0.9	0.402	2.2
	11/29/01		2.7	5.69	0.5
	12/18/01	310	1.67	0.271	6.2
	1/22/02	400	1.5	0.202	7.4
	2/28/02	295.8	0.95	0.20	4.8
	3/27/02	970	1.72	0.28	6.1

	4/11/02		1.1	0.22	5.0
	5/15/02		1.26	0.39	3.2
	6/4/02	39.04	1.27	0.42	3.0
	3/19/03		1.42	0.85	1.7
	4/3/03		0.64	0.2	3.2
				Average	3.9
HARPE084.4WI	3/19/03		1.3	1.1	1.2
	4/3/03		0.78	0.27	2.9
				Geometric Mean	1.8
HARPE087.7DA	3/19/03		1.16	0.76	1.5
	4/3/03		0.43	0.12	3.6
				Geometric Mean	2.3

Table D-2 Water Quality Monitoring Data – TN/TP Ratio (Continued)

Monitoring Station	Sample Date	Flow [cfs]	Total Nitrogen [a] [mg/l]	Total Phosphorus [mg/l]	TN/TP
HARPE092.4WI	10/10/01	16.22	0.76	0.404	1.9
	11/29/01		1.12	3.22	0.3
	12/18/01	360	1.58	0.227	7.0
	1/22/02	460	1.23	0.142	8.7
	2/28/02	160	0.54	0.18	3.0
	3/27/02	500	1.15	0.21	5.5
	4/11/02	193	0.48	0.15	3.2
	5/15/02		1.08	0.34	3.2
	6/4/02	24.56	0.84	0.28	3.0
				Geometric Mean	3.0
JONES019.6DI	11/13/01	10.3	0.67	0.118	5.7
	12/5/01	48.47	1.8	0.027	66.7
	2/19/02	13.47	0.45	0.22	2.0
	3/27/02		1.01	0.34	3.0
	4/25/02	23.49	1.49	0.16	9.3
	5/14/02	56.17	0.98	0.10	9.8
	6/12/02	8.08	1.5	0.54	2.8
				Geometric Mean	6.7
KELLE000.4RU	10/9/01	2.57	0.08	0.002 [c]	40.0
	11/8/01	0.54	0.49	0.187	2.6
	12/12/01	36.07	0.74	0.030	24.7

	1/29/02	91.57	0.36	0.116	3.1
	2/21/02	18.06	0.4	0.04	10.0
	3/18/02		0.22	0.18	1.2
	4/10/02	64.52	0.15	0.002 [c]	75.0
	5/23/02	3.71	0.56	0.024	23.3
	6/11/02	0.54	0.95	0.03	31.7
				Geometric Mean	12.1
LHARP001.0WI	10/18/01	14.85	1.76	0.367	4.8
	11/20/01	1.33	0.27	0.250	1.1
	12/13/01	218.9	0.54	0.353	1.5
	1/23/02	160	1.26	0.848	1.5
	2/28/02	29.3	1.1	0.18	6.1
	4/11/02	41.28	0.82	0.18	4.6
	5/15/02	94.36	1.33	0.26	5.1
	6/4/02	5.5	1.13	0.32	3.5
				Geometric Mean	3.0

Table D-2 Water Quality Monitoring Data – TN/TP Ratio (Continued)

Monitoring Station	Sample Date	Flow [cfs]	Total Nitrogen [a] [mg/l]	Total Phosphorus [mg/l]	TN/TP
PUCKE000.9RU	10/9/01	0.45	0.33	0.002 [c]	165
	11/8/01	0.01	0.14	0.002 [c]	70.0
	12/12/01	2.57	0.38	0.12	31.7
	1/29/02	1.87	0.3	0.019	15.8
	2/21/02	1.33	0.15	0.02	7.5
	4/10/02	0.42	0.17	0.002 [c]	85.0
	5/26/02	0.06	0.29	0.002 [c]	145
				Geometric Mean	47.4
WHARP017.7WI	10/10/01	1.82	0.96	0.394	2.4
	11/29/01		1.14	3.80	0.3
	12/18/01	66.93	2.69	0.349	7.7
	1/22/02	23.37	2.27	0.244	9.3
	2/26/02	23.37	1.72	0.21	8.2
	3/26/02		2.21	0.47	4.7
	4/8/02	36.92	1.77	0.28	6.3
	5/6/02	47.83	1.52	0.34	4.5
	6/25/02	2.10	1.38	0.579	2.4
				Geometric Mean	3.7

Notes: a. Sum of NO_3+NO_2 and TKN.

b. Multiple samples taken on date indicated. Values shown reflect sample with most parameters analyzed.

c. Sample reported as <0.004, 0.002 (½ of detection level) used for calculation of TN/TP ratio.

APPENDIX E

Class II Concentrated Animal feeding Operation General Permit

State of Tennessee

Department of Environment and Conservation

Division of Water Pollution Control

Class II Concentrated Animal Feeding Operation General Permit

Permit Number: TNA000000

I. REGULATORY AUTHORITY FOR THIS GENERAL PERMIT

This general permit is implemented under the authority of the Tennessee Water Quality Control Act of 1977, Chapter 1200-4-10 of the Rules of the Tennessee Department of Environment and Conservation (TDEC), and the National Pollutant Discharge Elimination System (NPDES) program delegation from the United States Environmental Protection Agency (USEPA).

II. DEFINITIONS

A. An “Animal Feeding Operation” (AFO) is a facility that stables or confines, and feeds or maintains animals for a total of 45 days or more in any 12-month period and does not sustain crops, vegetation forage growth, or post-harvest residues in the normal growing season over any portion of the facility.

B. A “Concentrated Animal Feeding Operation” (CAFO) is an animal feeding operation which meets the criteria in Section VI.B.1 or 2 of this general permit, or which the Division designates under Section VI.B.3 or 4 of this general permit.

C. A “Catastrophic Event” is a rainfall event equal to or greater than the 24-hour, 25-year storm, or the occurrence of a tornado or other severe event as determined by the Division which would cause an overflow from the waste retention structure.

D. A “Chronic Event” is a series of wet weather conditions that preclude de-watering of waste retention structures that are maintained in accordance with the waste handling system plan.

E. “Division” is the Division of Water Pollution Control.

F. “Existing Operation” means a facility that began feeding animals on or before May 1, 1999.

G. “Expanded Operation” means a facility that will increase the number of animals being fed above the design basis previously approved by TDA.

H. "Mature Dairy Animal" means a dairy cow that has reached the level of maturity to be milked on a daily basis. For CAFO counting purposes, this term applies only to animals that are being actively milked, and are regularly confined in a central area where wastes are concentrated. This definition shall not apply to heifers and dairy cows that are not being milked on a daily basis and are being kept on pasture.

I. "New Operation" means a facility that began feeding animals after May 1, 1999.

J. "NRCS" is the United States Department of Agriculture, Natural Resources Conservation Service.

K. "Sinkhole" means a depression in a karst area, commonly with a circular pattern. Its drainage is subterranean, its size is measured in meters and tens of meters, and is commonly funnel shaped. This definition is contained in the Fourth Edition of the Glossary of Geology.

L. "TDA" is the Tennessee Department of Agriculture.

M. "Wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

III. DISCHARGE PROHIBITED

Any discharge of wastewater from a CAFO is prohibited, unless such discharge results from a catastrophic or chronic storm event.

IV. STEPS FOR OBTAINING COVERAGE UNDER THIS GENERAL PERMIT

This general permit for concentrated animal feeding operations (CAFOs) is issued by the Division of Water Pollution Control (Division). Review and approval of all nutrient management plans and waste handling system plans required under this general permit will be performed by the Tennessee Department of Agriculture (TDA).

A. **New Operations.** CAFOs that begin feeding animals after May 1, 1999, which meet the provisions of Section VI.B.1 or VI.B.2 of this general permit, or AFOs that are designated as CAFOs by the Division per VI.B.3 or VI.B.4 of this general permit, must do the following:

1. Complete a Notice of Intent (NOI) form, which can be obtained from any of TDEC's Environmental Assistance Centers (1-888-891-TDEC), Agricultural Extension Service Offices, or from TDA. Attached to this form shall be:

    a. One copy of a nutrient management plan for the CAFO that meets the requirements of Section VIII.B of this general permit;

b. If liquid manure will be managed, the NOI must also have attached one copy of a waste handling system plan for the CAFO that meets the requirements of Section VIII.C of this general permit.

2. Submit the NOI and the required attachments to TDA per Section VII.C of this general permit for review. Upon approval, TDA will forward the completed NOI to the Division. TDA will also return copies of the approved documents to both the preparer and the operator. Upon receipt of the NOI, the Division will send a letter of coverage to the operator of the CAFO.

3. In all cases, new CAFOs shall meet the provisions of this general permit on or before the date they begin feeding animals.

B. Existing Operations. CAFOs that began feeding animals on or before May 1, 1999, which meet the provisions of Section VI.B.1 or VI.B.2 of this general permit, or AFOs that are designated as CAFOs by the Division per VI.B.3 or VI.B.4 of this general permit, must do the following:

1. Complete a NOI form, which can be obtained from any of TDEC's Environmental Assistance Centers (1-888-891-TDEC), Agricultural Extension Service Office, or from TDA.

2. Submit the NOI to TDA. TDA will forward the completed NOI to the Division. The Division will issue a letter of coverage to the existing CAFO, which will include a schedule of compliance. This schedule of compliance will contain the following requirements:

a. On or before May 1, 2001, the operator shall submit to TDA one copy of a nutrient management plan, consistent with Section VIII.B of this general permit; and

b. On or before May 1, 2001, the operator of a liquid waste handling system shall:

i. either submit one set of design drawings for any necessary modifications to the system;

ii. or submit a report to TDA, which documents a history of system performance and demonstrates compliance with the provisions of this general permit. The operator should consult with TDA to obtain a copy of the report format.

c. If construction is necessary to meet the provisions of this general permit, the operator shall complete the work within 1 year of the plans approval date by TDA.

3. In all cases, existing CAFOs shall meet the provisions of this general permit no later than May 1, 2001, except for completion of construction per IV.B.2.c above.

C. Expanding Operations

1. CAFOs that are already covered under this general permit, that intend to increase the numbers of animals to a level above the design basis previously approved by TDA, must have an approved updated system design before the CAFO begins feeding the additional animals.

2. Existing operations that desire to expand prior to receiving approval from TDA for their current operations, shall have an approved system to accommodate the increased number of animals by May 1, 2001. Facilities that choose to expand operations after May 1, 2001, shall be given one year to have an approved system to accommodate the increased number of animals.

V. TERM OF GENERAL PERMIT AND AUTHORIZATION

This general permit shall be effective from May 1, 1999, until April 30, 2004. Any persons who have submitted a Notice of Intent (NOI) and have not been told to apply for an individual permit will be mailed a letter of coverage per Section IV of this general permit and will be authorized to operate a Class II CAFO in accordance with all conditions of this general permit, their nutrient management plan and their waste handling system plan.

VI. COVERAGE UNDER THIS GENERAL PERMIT

A. General Permit Area. For existing facilities**,** the general permit is issued for all areas of Tennessee which have been identified as being located in watersheds of 303(d) listed streams identified as being impacted due to livestock operations

New facilities that meet the size criteria of Section VI, B,1 or VI, B, 2 and which locate in Tennessee after May 1, 1999, must obtain a Class II CAFO permit, regardless of their location in the state.

B. Applicability.

1. **Single Species Operations.** The provisions of this general permit apply to existing AFOs that confine the following numbers of livestock, and the operations are located in watersheds of stream segments specifically identified as impacted due to livestock operations that are identified in the 303(d) list of impaired waters for the State of Tennessee. The provisions of this general permit also apply to all new AFOs that confine the following numbers of livestock, and that propose to locate in Tennessee after May 1, 1999.

ANIMAL TYPE	LIQUID MANURE MANAGEMENT	DRY MANURE MANAGEMENT
Poultry (broilers and/or laying hens)	9,000 up to 30,000 birds	50,000 or greater(existing operations), 20,000 or greater (new operations)
Swine	751-2500 over 55 pounds each	751 or greater
Dairy (Mature Animals)	201-700	201 or greater`
Slaughter and Feeder Cattle	301-1000	301 or greater
For all other commercial species, the number of animals contained in 40 CFR Part 122, Appendix B, shall apply		

2. **Combined Species Operations.** This general permit also applies to combined operations having 301 to 1,000 animal units based on the following categories; and the operations are located in watersheds of stream segments specifically identified as impacted due to livestock operations that are identified in the 303(d) list of impaired waters for the State of Tennessee.

Dairy Cattle:	1.4 animal units per head
Slaughter and Feeder cattle:	1.0 animal unit per head
Swine:	0.4 animal units per head

3. **Case-by-Case Designation of CAFOs.** The Division may designate any AFO with fewer animals as a Class II CAFO upon determining that it is a contributor of pollution to the waters of the State.

a. In making this designation the Division shall consider the following factors:

i. The size of the AFO and the amount of waste reaching waters of the State;

ii. The location of the AFO relative to waters of the State;

iii. The means of conveyance of animal wastes and process waste waters into waters of the State;

iv. The slope, vegetation, rainfall, and other factors affecting the likelihood or frequency of discharge of animal waste and process waste waters into waters of the State.

b. No AFO with less than the numbers of animals set forth in Section VI.B.1 of this general permit shall be designated by the Division as a CAFO unless:

i. Pollutants are discharged into waters of the State through a man-made ditch, flushing system, or other similar man-made device; or

ii. Pollutants are discharged directly into waters of the State which originate outside of the facility and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation.

c. Coverage under this general permit shall not be required from an AFO designated under this section until the Division has conducted an on-site inspection of the operation and determined that the operation should and could be regulated under this general permit.

4. **Operator-Requested Designation.** Upon the request of the operator, the Division may designate any AFO with fewer animals than listed in VI.B.1 or VI.B.2 as a Class II CAFO to be covered under this general permit. All terms and provisions of this general permit will be applicable. Such operator may also request to have the designation terminated, and this request will be granted unless the conditions for case-by-case designation are found.

5. **Limitations on Coverage**. The following activities are not authorized by this general permit.

   CAFOs for poultry, ducks, turkeys, swine, dairy, slaughter and feeder cattle, sheep or lambs, or horses which confine numbers of animals in excess of those listed in Section VI.B.1 or VI.B.2 of this general permit. These CAFOs are considered Class I and will be covered under individual NPDES permits.

VII. NOTIFICATION REQUIREMENTS

A. Deadlines for Notification

1. **Existing Operations.** Any CAFO that desires coverage under this general permit shall submit an NOI to TDA by August 1, 1999.

2. **New Operations.** Any new CAFO that begins feeding animals after May 1, 1999, shall obtain coverage under this general permit, and shall submit an NOI at least 30 days prior to feeding animals at the facility.

3. **Ownership Change**: Whenever the person, firm, organization, or other entity that operates the CAFO covered under this general permit changes, notification of change of ownership shall be submitted to the Division.

B. Contents of Notice of Intent

1. **Facility Operator**. The name of the person, firm, organization, or other entity which operates the subject facility, the mailing address where correspondence should be sent and the name and phone number of a contact person.

2. **Facility Identification**. The legal and official name of the operation, and the address or location of the operation as well as the name and phone number of a contact person.

3. **Nearby Waters and Site Location Information**. A USGS topographic map, a county tax map or a soil map showing the acreage of the operation, and the name of the water body nearest the operation.

4. **Certification and Signature**. The certification statement shall be signed in accordance with Section VIII.A of this general permit.

C. Where to Submit

NOIs are to be submitted, along with all required attachments, to the Tennessee Department of Agriculture at the following address:

CAFO Notice of Intent

Tennessee Department of Agriculture

Ellington Agricultural Center

Nashville, TN 37204

VIII. GENERAL CONDITIONS

A. Signatory Requirements. All NOIs, requests for termination of general permit coverage, or other information submitted to the Division or to TDA shall be made in writing .

1. Signature. All information required or requested to be submitted by the Division or TDA shall be signed as follows:

a. For a corporation: by a responsible corporate officer. For the purpose of this section, a responsible corporate officer is the president, secretary, treasurer or vice-president of the corporation, or any other person who performs similar policy or decision-making functions for the corporation; or

b. For a partnership or sole proprietorship: by a general partner or the proprietor; or

c. A duly authorized representative. For the purpose of this section, a duly authorized representative is the person identified in writing to the Division or TDA who has been given the authority to sign for the person described in VIII.A.1.(a) or (b) above.

2. Certification. Any person signing documents under this section shall make the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the site, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

B. Nutrient Management Plan (NMP). For any new CAFO, the applicant shall obtain approval from TDA for the nutrient management plan per Section IV.A of this general permit. For an existing CAFO, the applicant shall obtain approval from TDA for the nutrient management plan per Section IV.B of this general permit. The NMP is to be generally consistent with the current NRCS *Field Office Technical Guide* and the NRCS *Agriculture Waste Management Field Handbook* or other NMP approved by TDA. The NMP shall contain the following:

1. Aerial site photographs or maps and soil maps showing the location of animal waste application fields and the location of all nearby streams, lakes, wetlands and known sinkholes;

2. Current and planned plant production sequence and rotation;

3. Identification of non-application buffer strips around the application site(s) that are sufficient to protect water quality;

4. Soil test results for phosphorus and potassium for application sites;

5. Nitrogen budget for application fields which accounts for all applied sources and realistic yield expectations;

6. Proposed application method and schedule; and

7. Dead animal disposal method.

Land application of animal waste shall be in accordance with the approved NMP, the Clean Water Act, and its implementing regulations. An operator desiring to make changes to their NMP shall notify and receive approval from TDA.

C. Liquid Waste Handling System. Liquid animal waste treatment and/or storage systems, or expansions to existing liquid waste handling facilities, shall be designed by a registered Professional Engineer, licensed to practice in Tennessee by the State Board of Architectural and Engineering Examiners, or by a person with engineering approval authority from the NRCS. Dry manure management systems that exceed 5 days' unprotected exposure of waste will be considered liquid waste management systems, and may require an individual NPDES permit. The plans for the treatment system shall bear the seal of the Professional Engineer or shall contain the verification of the NRCS approval authority. Liquid waste handling system plans will include the following:

1. A map indicating the location of streams, lakes, known sinkholes and other potentially sensitive areas or resources (e.g. wetlands);

2. A description of the proposed system and all system components and practices. Design and performance of waste handling systems must provide for no discharge, except as may be associated with catastrophic or chronic storm events;

3. For new operations only, setbacks from existing residential structures, streams, lakes and sinkholes that are adequate to protect water quality, public health, well heads and groundwater, consistent with the guidelines found in the NRCS *Field Office Technical Guide*; and

4. For new operations only, a soil and geological suitability report including site evaluation criteria contained in NRCS *Agricultural Waste Management Field Handbook* (AWMFH);

5. Liquid waste handling facilities shall be designed, constructed and operated to contain all process generated waste waters plus the runoff from a 25-year, 24-hour rainfall event.

6. In the event of a discharge from the liquid waste handling facility to waters of the state, during a chronic or catastrophic rainfall event, or in the event of an unpermitted discharge, upset or bypass of the system, a sample of the discharge shall be collected and analyzed for the following parameters: fecal coliform, 5-day biochemical oxygen demand, total

suspended solids, total nitrogen, total phosphorus, copper and zinc, or pesticide and other pollutants which the owner/operator has reason to believe could be present in the discharge. Results of analyses shall be mailed to the Division of Water Pollution Control at the appropriate EAC Office address provided in Section I,3.

7. Any such discharge to waters of the state shall not cause or contribute to an exceedance of Tennessee's water quality standards.

D. Record Keeping. Records shall be retained by the owner at the facility location for a minimum of two years, and shall contain the following:

1. Soil test results and recommended nutrient application rates;
2. Quantities and sources of all nutrients applied;
3. Dates and methods of applications;
4. Type of crop and dates planted;
5. Harvest dates and yields including residue removed;
6. Manure nutrient analysis;
7. Certificates, licenses and permits, as may be required; and
8. Quantities of manure transported off-site, including the recipient, date and volume transported and the final destination and end use of material.
9. Notification of any discharges or overflows to waters of the State;
10. Records of "freeboard" necessary to contain all process generated waste waters plus the runoff from a 25-year, 24-hour rainfall event.
11. Results of any sampling or analysis of pollutants discharged to waters of the State.

E. Dead Animal Disposal. The CAFO shall provide appropriate disposal of dead animals by composting, rendering, incineration, disposal in a Class I permitted landfill or burial on-site, in accordance with a nutrient management plan as approved by TDA, unless necessitated by emergency.

F. Inspection. Any duly authorized officer, employee or representative of TDEC or EPA may, upon presentation of credentials, enter and inspect any property, premises or place on or related to the collection, treatment, storage and land application of wastes, except for production facilities where bio-security is a concern, at any reasonable time for the purpose of determining compliance with this general permit. Staff may inspect and obtain a copy of any records that must be kept under the terms and conditions of this general permit; and may obtain samples of the wastewater, groundwater or surface water.

G. Closure of Liquid Manure System. If a liquid manure handling system is to be taken out of operation at a permitted facility, the permittee shall empty the waste storage pond or structure and shall remove any residual waste.

H. Termination of General Permit. An operator of a CAFO covered under this general permit shall notify the Division, at the address listed below, when the CAFO is no longer in operation.

CAFO General Permit Termination

Division of Water Pollution Control

401 Church Street- 6th Floor Annex

Nashville, TN 37243-1534

I. Emergencies. Should the facility experience a discharge of animal waste or another emergency that has the potential to impact waters of the state, the permittee should notify the Division as follows:

1. By telephone, immediately upon occurrence, 1-888-891-TDEC, for discharges:

    a. Resulting from non-precipitation events (e.g. structural failure, equipment breakdown, human error); or

    b. That threaten to cause a fish kill; or

    c. That threaten potable water supplies; or

    d. That otherwise threaten public health.

2. In writing, within 5 days of occurrence, with the following information:

    a. Cause of the discharge;

    b. Period of discharge, including exact times and dates;

    c. An estimation of the discharge volume;

    d. Location of discharge to waters of the state; and

    e. Corrective steps taken.

3. The completed report shall be mailed to:

CAFO Discharge Report

Tennessee Division of Water Pollution Control

(to the appropriate Environmental Assistance Center listed below):

EAC counties and addresses are listed from West to East Tennessee.

Fayette, Shelby and Tipton Counties:

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

2510 MT MORIAH ROAD SUITE E-645

MEMPHIS TN 38115-1520

Benton, Carroll, Chester, Crockett, Decatur, Dyer, Gibson, Hardeman, Hardin, Haywood, Henderson, Henry, Lake, Lauderdale, McNairy, Madison, Obion, Weakly counties:

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

362 CARRIAGE HOUSE DRIVE

JACKSON TN 38305-2222

Cheatham, Davidson, Dickson, Houston, Humphreys, Montgomery, Robertson, Rutherford, Stewart, Sumner, Williamson, Wilson:

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

537 BRICK CHURCH PARK DRIVE

NASHVILLE TN 37243-1550

Bedford, Coffee, Franklin, Giles, Hickman, Lawrence, Lewis, Lincoln, Marshall, Maury, Moore, Perry, Wayne

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

2484 PARK PLUS DRIVE

COLUMBIA TN 38401

Cannon, Clay, Cumberland, DeKalb, Fentress, Jackson, Macon, Pickett, Putnam, Overton, Smith, Trousdale, Van Buren, Warren, White

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

1221 SOUTH WILLOW AVE

COOKEVILLE TN 38506

Bledsoe, Bradley, Grundy, Hamilton, McMinn, Marion, Meigs, Polk, Rhea, Sequatchie

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

STATE OFFICE BUILDING SUITE 550

540 MCCALLIE AVE

CHATTANOOGA TN 37402

Anderson, Blount, Campbell, Claiborne, Cocke, Grainger, Hamblen, Jefferson, Knox, Loudon, Monroe, Morgan, Roane, Scott, Sevier, Union

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

2700 MIDDLEBROOK PIKE SUITE 220

KNOXVILLE TN 37921

Carter, Greene, Hancock, Hawkins, Johnson, Sullivan, Unicoi, Washington Counties

TN DEPT OF ENV AND CONSERVATION

DIVISION OF WATER POLLUTION CONTROL

2305 SILVERDALE ROAD

JOHNSON CITY TN 37601

J. **Duty to Mitigate**. The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this general permit.

K. **Liability for Damages**. Nothing in this general permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance. Additionally, notwithstanding this general permit, it shall be the responsibility of the permittee to conduct its operation in a manner such that public or private nuisances or public health hazards will not be created.

Nothing in this general permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or the Federal Water Pollution Control Act, as amended.

Coverage under this general permit shall not relieve the permittee of the responsibility for damages to surface waters or ground waters resulting from the operation of this facility in a manner not in accordance with any provision of this general permit.

A permittee who has submitted an NOI and received permit coverage has the duty to comply with all provisions of this Class II General Permit.

L. **Submittal of Other Information**. When the permittee becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in the NOI or in any other report to TDA or the Division, he or she shall promptly submit such facts or information.

CAFO_GP7 C:

APPENDIX F

Land Use Distribution in Impaired HUC-12 Subwatersheds

Table F-1 MRLC Land Use Distribution of Impaired HUC-12 Subwatersheds

Land Use	HUC-12 Subwatershed (05130204__)							
	0101		0102		0104		0105	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	6	0.03	70	0.24	158	0.40	219	0.66
Low Intensity Residential	182	0.80	85	0.29	337	0.84	2,521	7.57
High Intensity Residential	5	0.02	1	0.00	7	0.02	406	1.22
High Intensity Commercial /Industrial/Transportation	63	0.28	74	0.25	120	0.30	1,342	4.03
Bare Rock/Sand/Clay	0	0.00	0	0.00	0	0.00	0	0.00
Transitional	109	0.48	0	0.00	1	0.00	53	0.16
Deciduous Forest	7,363	32.54	6,866	23.61	11,189	27.97	7,431	22.30
Evergreen Forest	1,452	6.42	1,129	3.88	1,400	3.50	1,047	3.14
Mixed Forest	3,428	15.15	4,551	15.65	6,675	16.69	4,558	13.68
Pasture/Hay	5,790	25.58	12,221	42.03	15,559	38.90	8,355	25.08
Row Crops	4,118	18.20	3,733	12.84	3,951	9.88	4,681	14.05
Other Grasses (Urban/Recreational)	115	0.51	23	0.08	602	1.51	2,542	7.63

Woody Wetlands	0	0.00	310	1.07	0	0.00	24	0.07
Emergent Herbaceous Wetlands	0	0.00	12	0.04	0	0.00	0	0.00
Quarries/Strip Mines/Gravel Pits	0	0.00	0	0.00	0	0.00	141	0.42
Subtotal – Urban	359	1.59	160	0.55	465	1.16	4,322	12.97
Subtotal - Agriculture	9,908	43.78	15,954	54.87	19,510	48.78	13,056	39.12
Subtotal - Forest	12,358	54.61	12,891	44.34	19,866	49.67	15,743	47.25
Total	**22,631**	**100.00**	**29,075**	**100.00**	**39,999**	**100.00**	**33,320**	**100.00**

Table F-1 MRLC Land Use Distribution of Impaired HUC-12 Subwatersheds (Continued)

Land Use	HUC-12 Subwatershed (05130204__)							
	0201		0202		0301		0302	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	42	0.18	12	0.06	613	1.51	79	0.26
Low Intensity Residential	86	0.37	92	0.49	2,359	5.79	2,069	6.90
High Intensity Residential	0	0.00	3	0.02	345	0.85	81	0.27
High Intensity Commercial /Industrial/Transportation	107	0.46	19	0.10	517	1.27	755	2.52
Bare Rock/Sand/Clay	0	0.00	0	0.00	0	0.00	0	0.00
Transitional	40	0.17	0	0.00	15	0.04	0	0.00
Deciduous Forest	5,545	24.03	7,080	37.50	19,433	47.73	9,187	30.66
Evergreen Forest	494	2.14	246	1.30	1,199	2.94	1,682	5.61
Mixed Forest	2,713	11.76	1,724	9.13	5,286	12.98	6,317	21.08
Pasture/Hay	10,926	47.35	7,755	41.08	7,369	18.10	6,130	20.46
Row Crops	3,037	13.16	1,869	9.90	2,091	5.14	1,641	5.48
Other Grasses (Urban/Recreational)	83	0.36	80	0.42	1,354	3.33	2,025	6.76

Woody Wetlands	0	0.00	0	0.00	95	0.23	0	0.00
Emergent Herbaceous Wetlands	0	0.00	0	0.00	0	0.00	0	0.00
Quarries/Strip Mines/Gravel Pits	0	0.00	0	0.00	38	0.09	0	0.00
Subtotal – Urban	233	1.01	114	0.60	3,236	7.95	2,905	9.69
Subtotal - Agriculture	13,963	60.52	9,624	50.97	9,460	23.24	7,771	25.93
Subtotal - Forest	8,835	38.29	9,130	48.36	27,405	67.31	19,211	64.11
Total	**23,073**	**100.00**	**18,880**	**100.00**	**40,174**	**100.00**	**29,966**	**100.00**

Table F-1 MRLC Land Use Distribution of Impaired HUC-12 Subwatersheds (Continued)

Land Use	HUC-12 Subwatershed (05130204__)					
	0401		0601		0604	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Open Water	10	0.04	88	0.47	10	0.03
Low Intensity Residential	224	0.82	830	4.44	197	0.64
High Intensity Residential	39	0.14	213	1.14	10	0.03
High Intensity Commercial /Industrial/Transportation	52	0.19	590	3.15	99	0.32
Bare Rock/Sand/Clay	0	0.00	0	0.00	0	0.00
Transitional	2	0.01	7	0.04	78	0.25
Deciduous Forest	21,058	76.74	7,893	42.18	22,431	73.16
Evergreen Forest	182	0.66	511	2.73	393	1.28
Mixed Forest	753	2.74	1,384	7.40	1,652	5.39
Pasture/Hay	3,440	12.54	4,328	23.13	3,338	10.89
Row Crops	1,543	5.62	2,362	12.62	2,259	7.37
Other Grasses (Urban/Recreational)	136	0.50	411	2.20	159	0.52

Woody Wetlands	0	0.00	0	0.00	34	0.11
Emergent Herbaceous Wetlands	0	0.00	0	0.00	0	0.00
Quarries/Strip Mines/Gravel Pits	0	0.00	97	0.52	0	0.00
Subtotal – Urban	317	1.16	1,640	8.76	384	1.25
Subtotal - Agriculture	4,983	18.16	6,690	35.75	5,597	18.26
Subtotal - Forest	22,129	80.65	10,296	55.02	24,669	80.46
Total	**27,439**	**100.00**	**18,714**	**100.00**	**30,660**	**100.00**

APPENDIX G

Development of Nutrient TMDLs

DEVELOPMENT OF NUTRIENT TMDLS

Target nutrient concentrations for Level IV ecoregions 71f, 71h, & 71i were used to develop nutrient TMDLs for the Upper Duck River watershed using the procedure outlined below. Information regarding ecoregion reference sites in Tennessee can be found in *Tennessee Ecoregion Project, 1994-1999* (TDEC, 2000).

Development of Target Nutrient Loads for Level IV Ecoregions

1. Reference sites for Level IV ecoregions 71f, 71h, & 71i were identified (see Figure G-1) and the watershed, corresponding to USGS 8-digit hydrologic unit codes (HUCs), in which each site was located noted. This information is summarized in Table G-1.

Table G-1 Location of Level IV Ecoregion Reference Sites

Level IV Ecoregion	Reference Site	Stream	Watershed	
			Name	HUC
71f	ECO71F12	South Harpeth Creek	Harpeth	05130204
	ECO71F16	Wolf Creek	Lower Duck	06040003
	ECO71F19	Brush Creek	Buffalo	06040004
	ECO71F27	Swanegan Branch	Pickwick Lake	06030005
	ECO71F28	Little Swan Creek	Lower Duck	06040003
71h	ECO71H03	Flynn Creek	Upper Cumberland (Cordell Hull Lake)	05130106
	ECO71H06	Clear Fork	Caney Fork	05130108
	ECO71H09	Carson Fork	Stones	05130203
71i	ECO71I03	Stewart Creek	Stones	05130203

	ECO71I10	Flat Creek	Upper Duck	06040002
	ECO71I12	Cedar Creek	Cumberland (Old Hickory Lake)	05130201
	ECO71I14	Little Flat Creek	Upper Duck	06040002
	ECO71I15	Harpeth River	Harpeth	05130204

2. Using the Loading Simulation Program in C++ (LSPC), each 8-digit HUC containing a Level IV ecoregion reference site was calibrated for hydrology (LSPC is based on the Hydrological Simulation Program – Fortran [HSPF] and has been utilized extensively for pathogen TMDLs in EPA Region IV). The calibrations were performed over a 10-year period using an appropriate USGS continuous gaging station. Special attention was paid to total volume of water, both on a yearly basis as well as for the entire 10-year period. The hydrologic parameters in the calibrated model were validated where possible using another USGS continuous gaging station.

3. The calibrated watershed models were then utilized to simulate the daily flow at each ecoregion reference site for a 10-year period.

4. The proposed total nitrogen target concentration (ref. Section 4.2.2) was applied to the each daily flow at each ecoregion reference site to generate daily total nitrogen loads.

5. The average monthly total nitrogen loads for January were calculated for each site by summing the daily loads for each January during the 10-year period and dividing by 10. This process was repeated for all other months.

6. Average semiannual total nitrogen loads were calculated for reference sites by summing the average monthly loads for each six month period (May-October & November-April).

7. The average semiannual total nitrogen loads, on a unit area basis, were calculated for each ecoregion reference site by dividing the average semiannual loads (Step 6) by the corresponding reference site drainage areas. Average semiannual total nitrogen loads per unit area are shown in Table G-2 for each ecoregion reference site.

Table G-2 Average Semiannual Nutrient Loads for Ecoregion Reference Sites

Ecoregion Reference Site	Total Nitrogen		Total Phosphorus	
	May-Oct	Nov-Apr	May-Oct	Nov-Apr
	[lbs/ac/6 mo.]	[lbs/ac/6 mo.]	[lbs/ac/6 mo.]	[lbs/ac/6 mo.]
ECO71F12	0.5455	1.7255	0.0317	0.1002
ECO71F16	0.5161	1.0885	0.0300	0.0632

ECO71F19	0.6309	1.3213	0.0366	0.0767
ECO71F27	0.5484	1.0738	0.0318	0.0624
ECO71F28	0.6295	1.3169	0.0366	0.0765
ECO71H03	1.8732	4.3209	0.1544	0.3561
ECO71H06	0.8439	2.7838	0.0696	0.2294
ECO71H09	0.7452	2.9570	0.0614	0.2437
ECO71I03	0.7812	3.0813	0.1656	0.6530
ECO71I10	1.1073	3.4787	0.2347	0.7372
ECO71I12	1.4027	3.2069	0.2973	0.6796
ECO71I14	1.6895	3.6258	0.3580	0.7684
ECO71I15	1.1970	3.1854	0.2537	0.6751

8. The average semiannual total nitrogen load per unit area for Level IV ecoregion 71f was determined by calculating the geometric mean of semiannual total nitrogen loads per unit area (Step 7) of the five ecoregion 71f reference sites. The target average semiannual total nitrogen loads per unit area for Level IV ecoregions 71h (3 sites) & 71i (5 sites) were determined in a similar manner.

9. Steps 4 through 8 were repeated for total phosphorus. Target nutrient loads, on a unit area basis, for Level IV ecoregions 71f, 71h & 71i are summarized in Table G-3.

Table G-3 Target Semiannual Nutrient Loads for Level IV Ecoregions 71f, 71h, & 71i

Level IV Ecoregion	Total Nitrogen		Total Phosphorus	
	May-Oct [lbs/acre/6 mo.]	Nov-Apr [lbs/acre/6 mo.]	May-Oct [lbs/acre/6 mo.]	Nov-Apr [lbs/acre/6 mo.]
71f	0.5721	1.2854	0.0332	0.0746
71h	1.0561	3.2887	0.0870	0.2710
71i	1.1967	3.3095	0.2536	0.7014

Development of Nutrient TMDLs for Subwatersheds in the Harpeth River Watershed

Note: Calculations for Subwatershed 051302040102 (Harpeth River) are shown. The procedure for other subwatersheds is similar.

10. Since the Subwatershed 051302040102 is approximately 63% in ecoregion 71h and 37% in ecoregion 71i, target nutrient loads for the subwatershed as a whole were based on an area-weighted combination of the ecoregion target loads:

$$TMDL_{0102} = (TL_{71h})\ (A_{71h}) + (TL_{71i})\ (A_{71i})$$

where: $TMDL_{0102}$ = TMDL for Subwatershed 051302040102 [lbs/6 mo.]

TL_{71h} = Target load for ecoregion 71h [lbs/acre/6 mo.]

A_{71h} = Area of subwatershed in ecoregion 71h [acres]

TL_{71i} = Target load for ecoregion 71i [lbs/acre/6 mo.]

A_{71i} = Area of subwatershed in ecoregion 71i [acres]

As an example, for total nitrogen during the May-October time period as a 6-month average:

$$TMDL_{0102} = (1.0561 \text{ lbs/ac/6 mo.})\ (18{,}337 \text{ ac}) + (1.1967 \text{ lbs/ac/6 mo.})\ (10{,}741 \text{ ac})$$

$$TMDL_{0102} = 32{,}219 \text{ lbs/6 mo.}$$

Note: Calculations were performed using a spreadsheet program and may differ slightly from example values due to round off.

Semiannual nutrient TMDLs for selected HUC 12 subwatersheds are calculated in terms of a monthly average (i.e., dividing the semiannual load by 6) and are summarized in Table G-4.

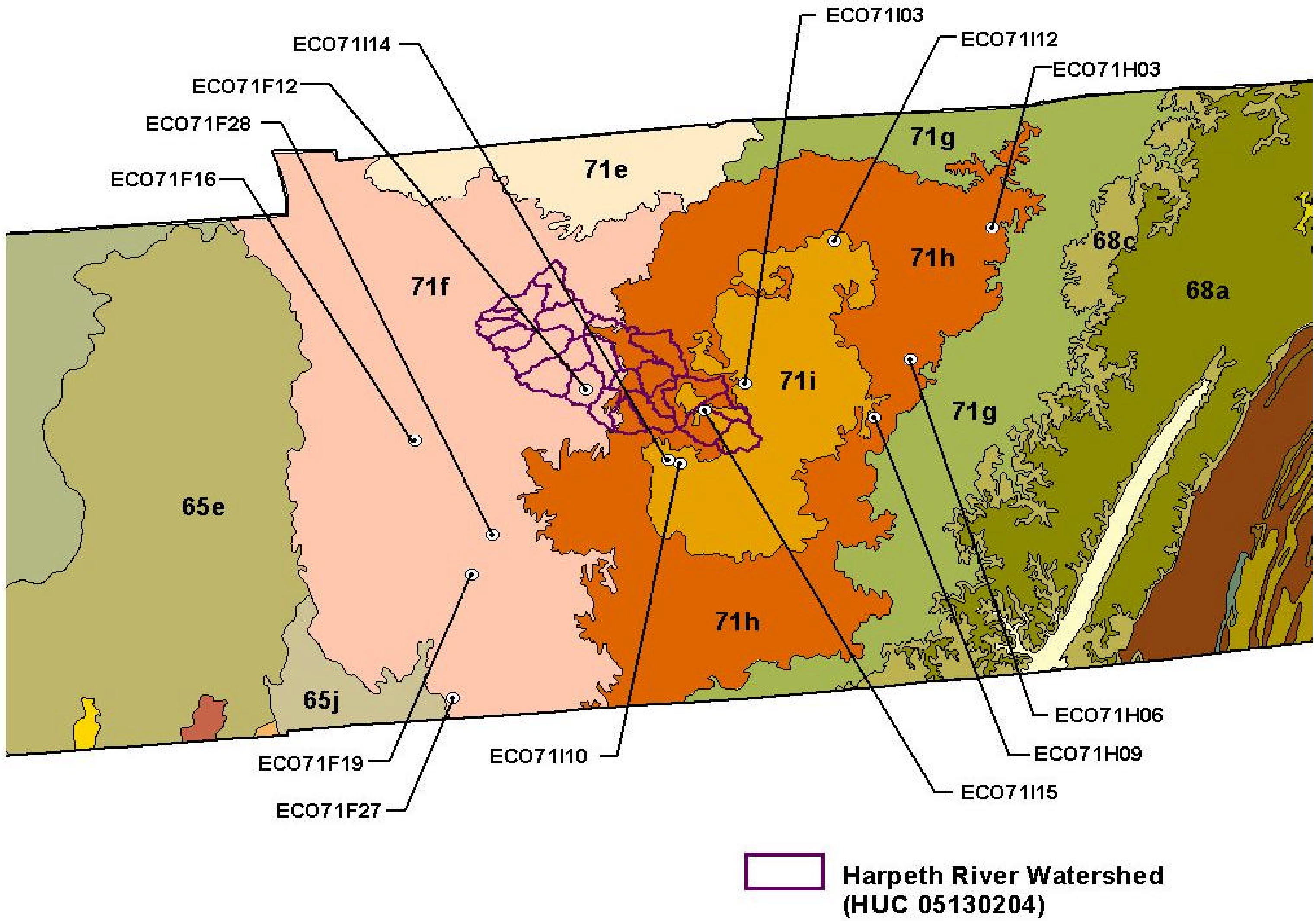
Table G-4 Nutrient TMDLs for Selected Impaired HUC-12 Subwatersheds

HUC-12 Subwatershed (05130204__)	Total Nitrogen		Total Phosphorus	
	Summer * [lbs/month]	Winter * [lbs/month]	Summer * [lbs/month]	Winter * [lbs/month]
0101	4480	12478	916	2541
0104	7335	21966	929	2709
0105	5864	18260	483	1505
0201	4062	12649	335	1042

0202	3026	9119	241	732
0301	6253	18537	489	1468
0302	5275	16425	435	1354

a. Summer: 5/1 – 10/31; Winter: 11/1 – 4/30.

Figure G-1 Reference Sites in Level IV Ecoregions 71f, 71h, & 71i



APPENDIX H

Estimation of Required Reduction in Nutrient Loading

The reductions in existing nutrient loading required to achieve specified TMDLs were estimated using load duration curves and water quality monitoring data.

Development of Load-Duration Curve and Estimation of Required Load Reductions

Nutrient load-duration curves for HUC-12 subwatersheds 0101, 0102, & 0104 were developed from the flow-duration curve of the Harpeth River at USGS continuous record station 03432350 at Franklin (RM 88.1), the appropriate drainage areas, and monitoring data collected in 1999 & 2000 using the following procedure:

1. A flow-duration curve for USGS 03432350 was constructed using daily mean flows for the period from 10/1/96 through 9/2/02. A flow duration curve is a cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the largest daily mean flow during this period is exceeded 0% of the time and the smallest daily mean flow is exceeded ~100% of the time). USGS 03432350 is a continuous record station located at RM 88.1 of the Harpeth River, at the Highway 96 bridge in Franklin.

2. Each ranked daily mean flow was divided by the drainage area upstream of the USGS station to create a flow-duration curve on a unit drainage area basis. (There is, therefore, a "percent of days that the flow per unit area is exceeded" associated with each of the 1,369 measured daily mean flows per unit area).

3. Each ranked daily mean flow on a unit area basis was multiplied by the drainage area upstream of water quality monitoring station HARPE092.4WI to create a flow duration curve for the Harpeth River at the station location.

4. A composite target total nitrogen concentration was determined for the HARPE092.4WI drainage area using the target concentrations for Level IV ecoregions 71h & 71i (ref.: Section 4.2.2) and the fraction of the drainage area in each ecoregion:

$$TN_{Composite} = \frac{[(TN_{71h})(DA_{71h})] + [(TN_{71i})(DA_{71i})]}{(DA_{71h} + DA_{71i})}$$

$$TN_{Composite} = \frac{[(0.728\ mg/l)(53{,}801\ acres)] + [(0.755\ mg/l)(54{,}503\ acres)]}{(53{,}801\ acres + 54{,}503\ acres)}$$

$$TN_{Composite} = 0.742\ mg/l$$

5. A target load-duration curve was generated for the Harpeth River at the HARPE092.4WI station location the by applying the composite target total nitrogen concentration to each of the 2,163 ranked flows:

   $(\text{Target Load})_{HARPE092.4WI} = (TN_{Composite})_{HARPE092.4WI} \times (Q) \times (UCF)$

   where: Q = daily mean flow
   UCF = the required unit conversion factor

6. Total Nitrogen loads were calculated for each of the samples collected at the HARPE092.4WI monitoring station (ref.: Table C-1) by multiplying the sample concentration by the measured flow (and the required unit conversion factor).

7. Using the flow duration curve developed in Step 3, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curve developed in Step 5 according to the PDFE. The resulting curve is shown in Figure H-1.

8. The percent load reduction corresponding to each sample load was determined through comparison with the target load corresponding to the PDFE. The overall reduction of existing nutrient load required to meet the TMDL target was <u>estimated</u> to be the geometric mean of the individual sample reductions. Negative reductions were not used in the estimation of the overall reduction.

   Note: The geometric mean was used in cases where the number of individual sample reductions was less than ten. The arithmetic mean (average) was used where the number of individual sample reductions was ten or greater.

9. Steps 1 through 8 were repeated for total phosphorus. The load duration curve for total phosphorus is shown in Figure H-2. Sample loads, target loads, PDFEs, and approximate required reductions in nutrient loading for the Harpeth River upstream of HARPE092.4WI are summarized in Table H-1. The estimated load reductions were applied to impaired subwatersheds 0101, 0102, & 0104.

Load duration curves for selected other HUC-12 subwatersheds containing waterbodies identified as impaired due to organic enrichment/low dissolved oxygen or nutrients are shown in Figures H-3 through H-8. Sample loads, target loads, PDFEs, and approximate required reductions in nutrient loading for these waterbodies are summarized in Tables H-2 through H-4.

Figure H-1 Total Nitrogen Load Duration Curve for the Harpeth River at HARPE092.4WI

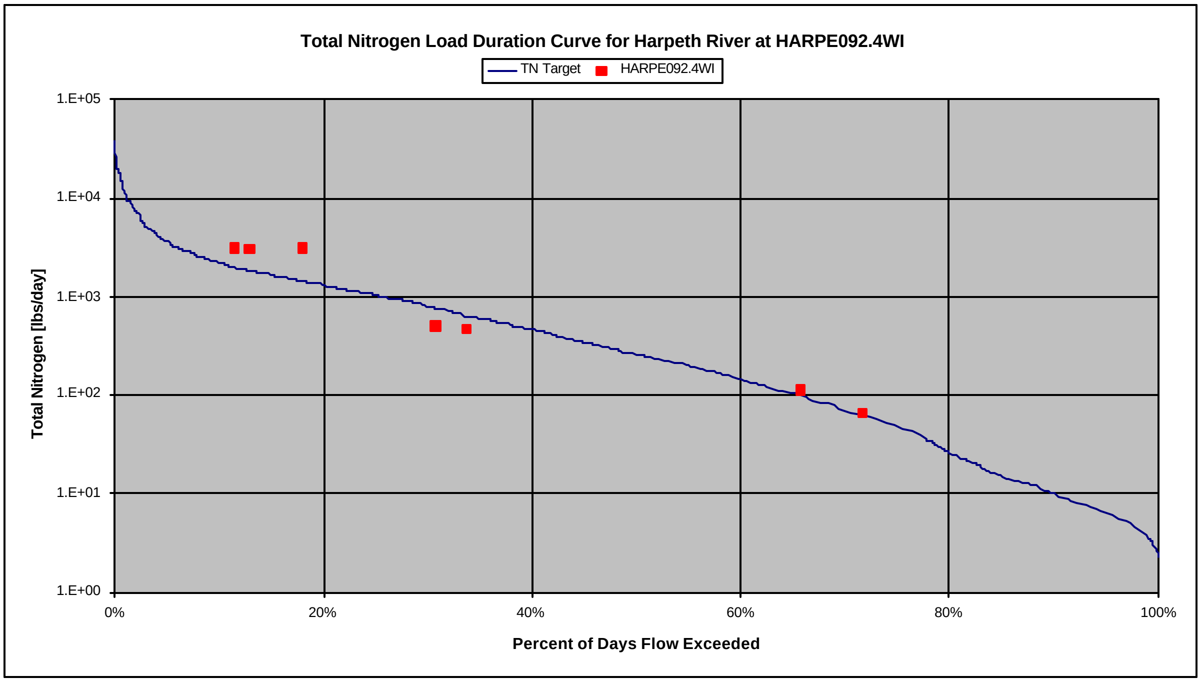


Figure H-2 Total Phosphorus Load Duration Curve for the Harpeth River at HARPE092.4WI

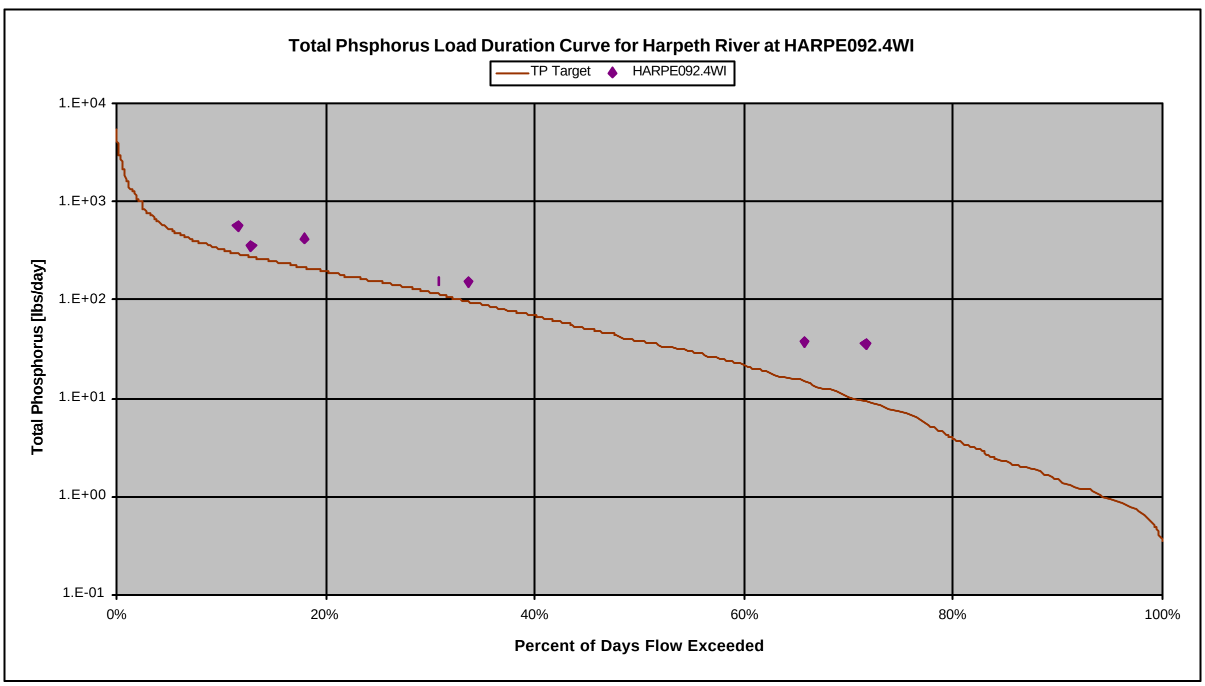


Figure H-3 Total Nitrogen Load Duration Curve for West Harpeth River at WHARP017.7WI

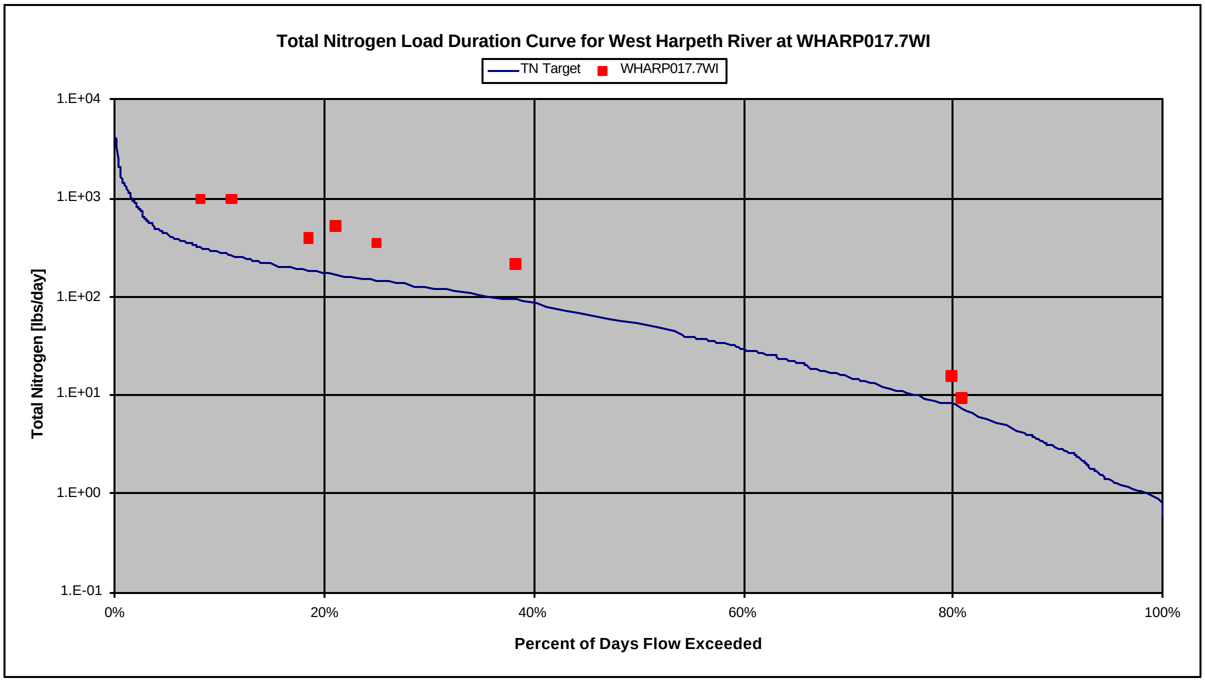


Figure H-4 Total Phosphorus Load Duration Curve for the W. Harpeth River at WHARP017.7WI

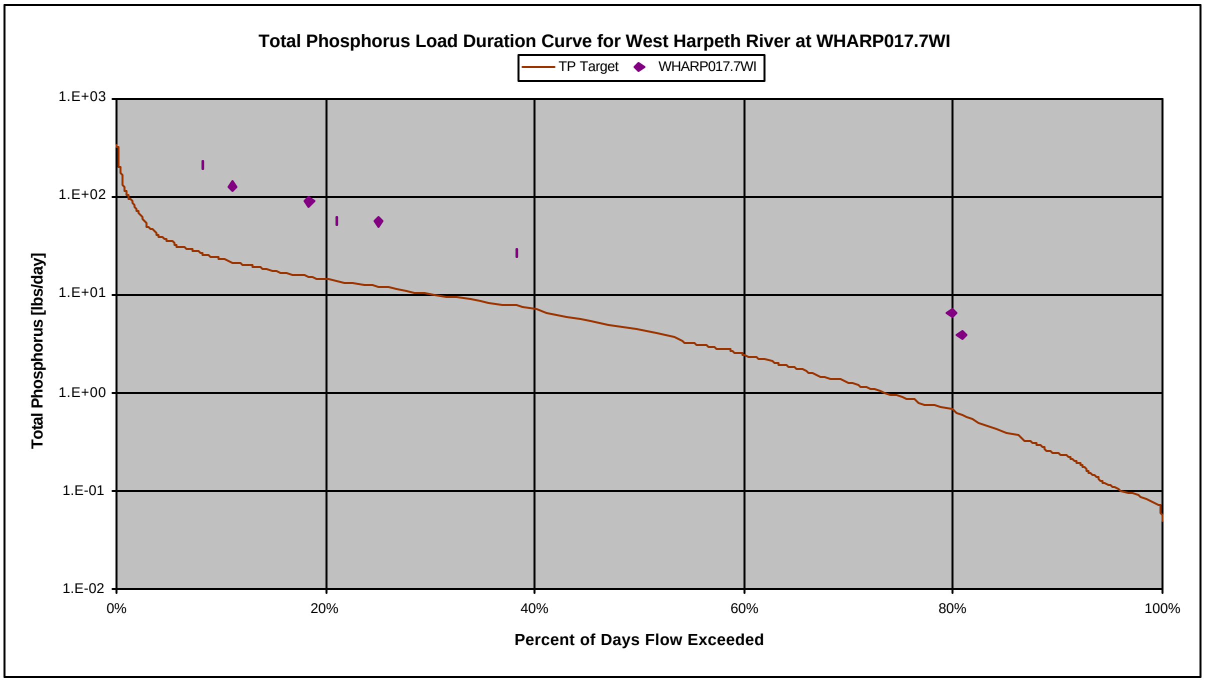


Figure H-5 Total Nitrogen Load Duration Curve for the Little Harpeth River at LHARP001.0WI

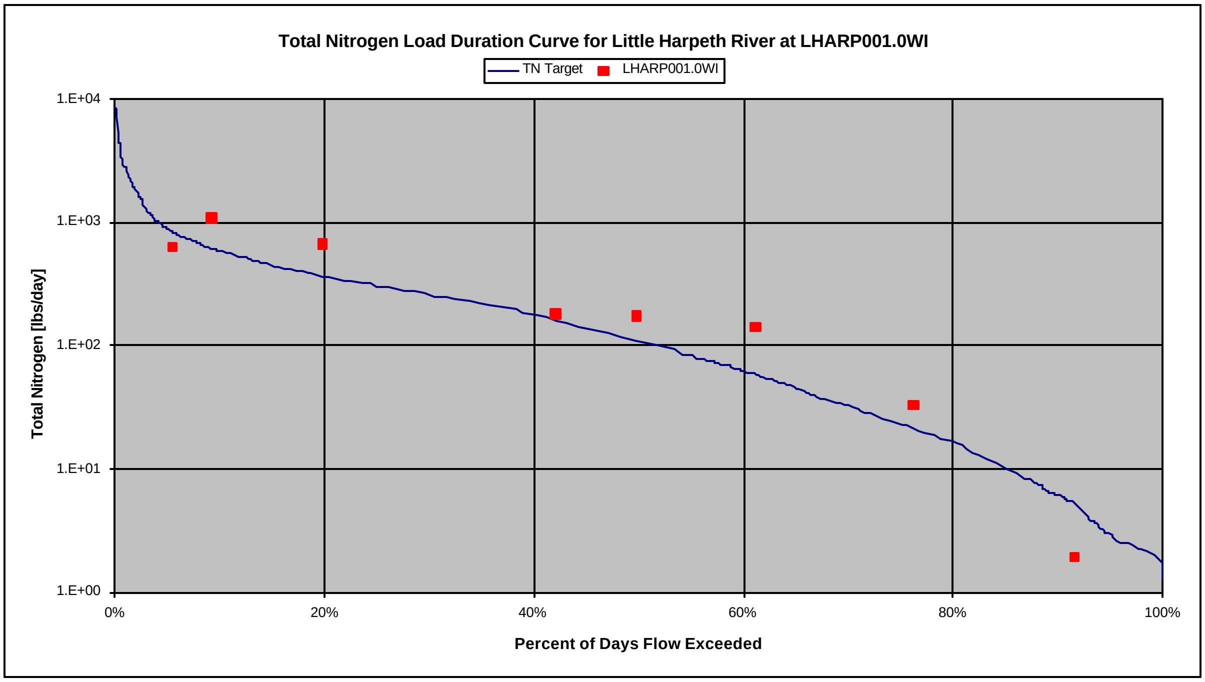


Figure H-6 Total Phosphorus Load Duration Curve for the Little Harpeth River at LHARP001.0WI

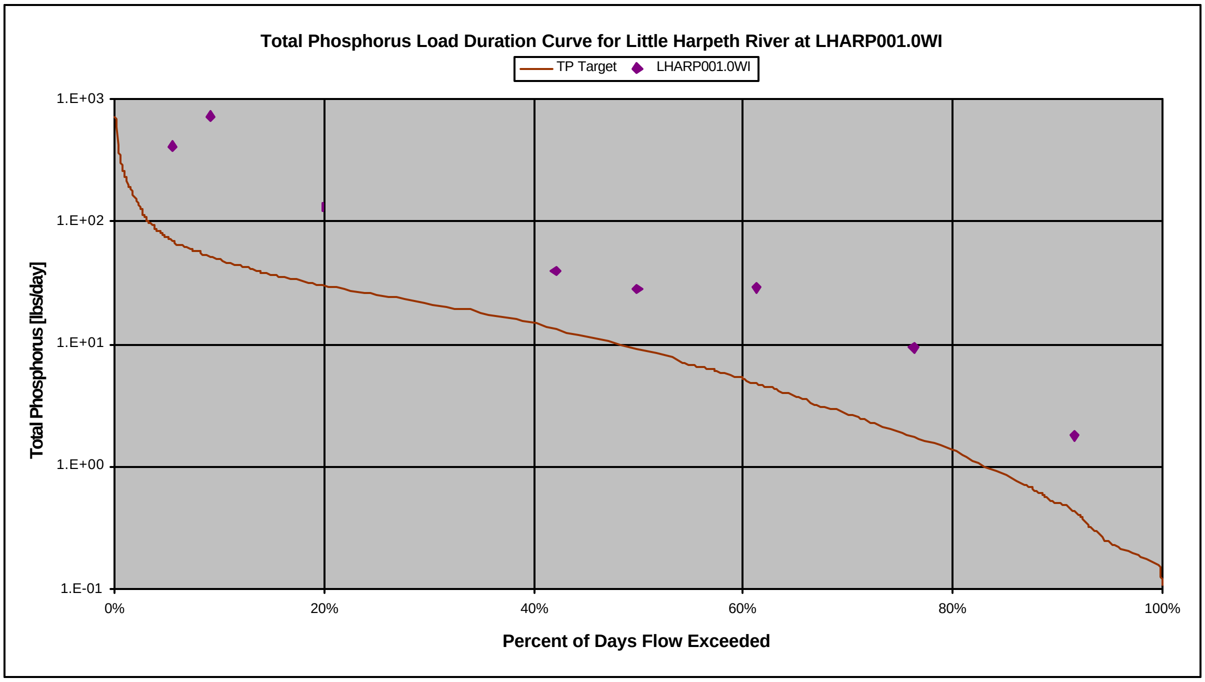


Figure H-7 Total Nitrogen Load Duration Curve for Arkansas Creek at ARKAN000.1WI

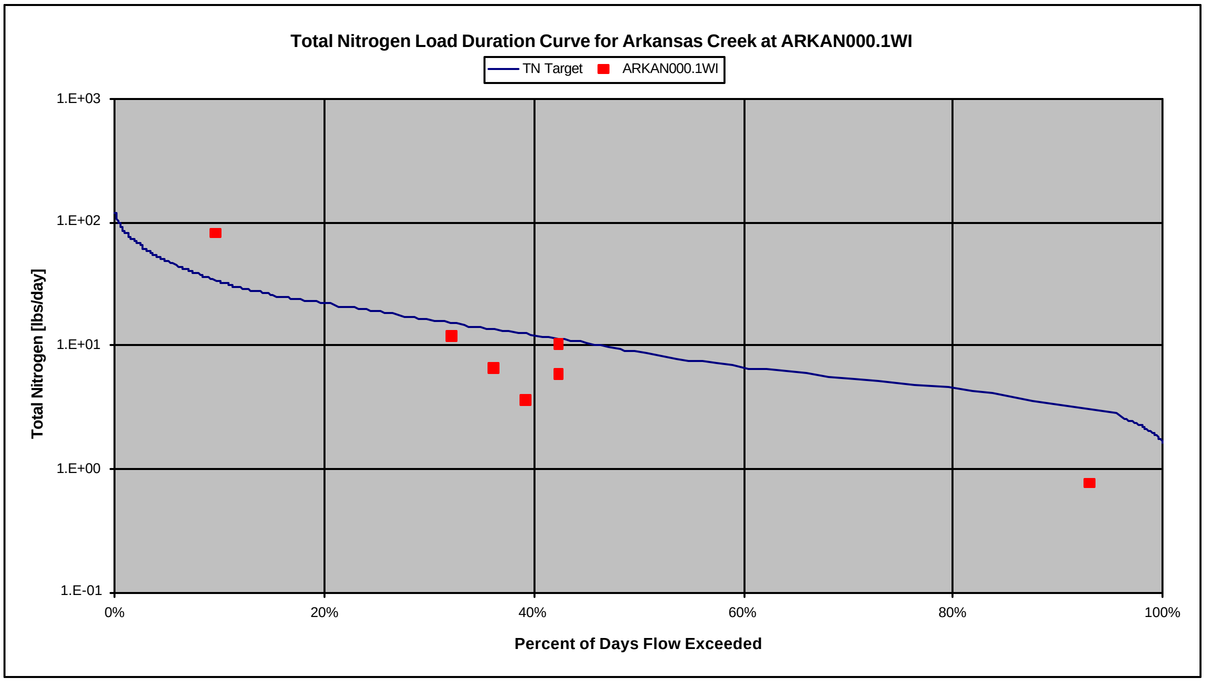


Figure H-8 Total Phosphorus Load Duration Curve for Arkansas Creek at ARKAN000.1WI

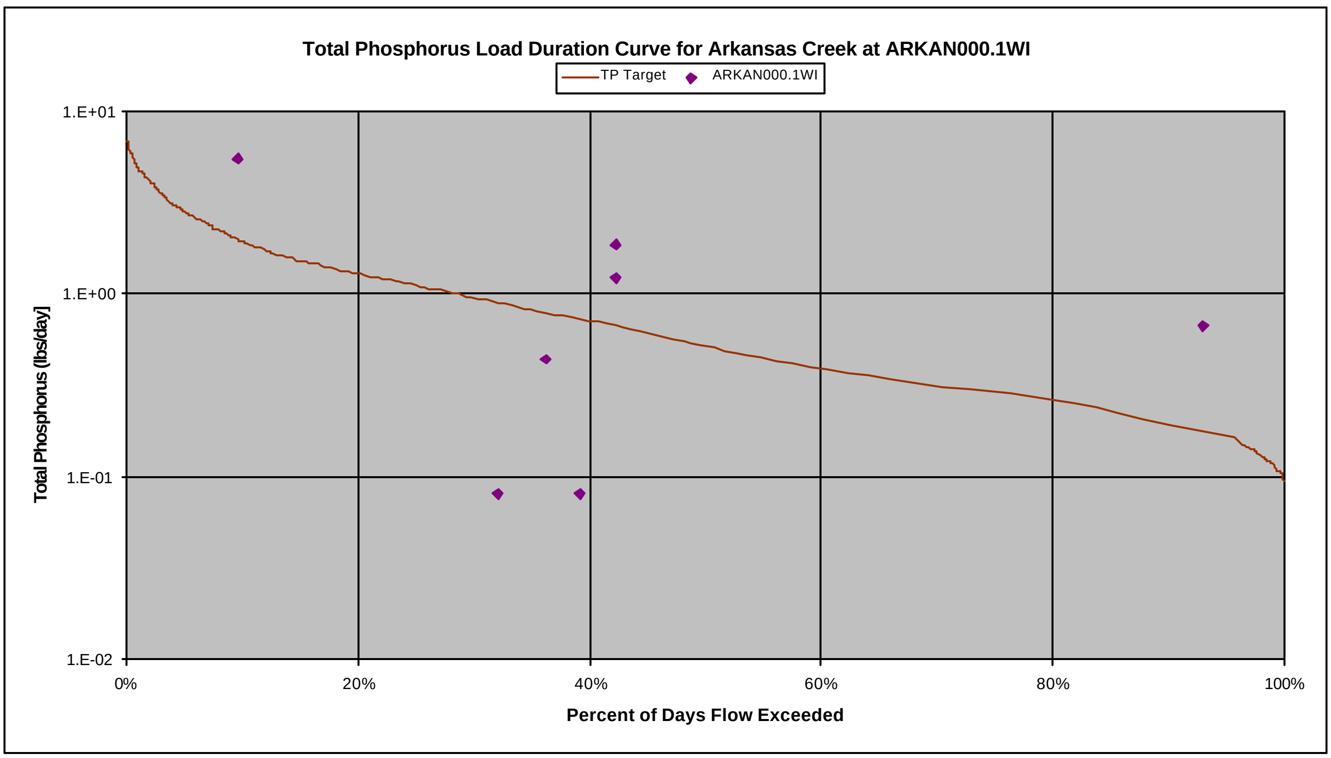


Table H-1 Determination of Estimated Overall Required Nutrient Reduction for Harpeth River at HARPE092.4WI

Sample Date	Flow	PDFE (Approx.)	Total Nitrogen				Total Phosphorus			
			Sample Concen. [a]	Sample Load	Target Load	Reqd. Reduction	Sample Concen.	Sample Load	Target Load	Reqd. Reduction
	[cfs]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]
10/10/01	16.22	71.6	0.76	66.46	63.79	4.0	0.404	35.33	9.46	73.2
12/18/01	360	18.0	1.58	3,066	1,439	53.1	0.220	427.0	213.3	50.0
1/22/02	460	12.9	1.23	3,050	1,839	39.7	0.142	352.2	272.7	22.6
2/28/02	160	33.7	0.54	465.8	641.5	NR [b]	0.180	155.3	95.10	38.8
3/27/02	500	11.6	1.15	3,100	1,999	35.5	0.210	566.1	296.3	47.7
4/11/02	193	30.8	0.48	499.4	769.1	NR [b]	0.150	156.1	144.0	27.0
6/4/02	24.56	65.8	0.84	111.2	99.24	10.8	0.280	37.07	14.71	60.3
			Geometric Mean ®			**20.0**	**Geometric Mean ®**			**42.4**

Notes: a. Value shown is the calculated sum of NO_3+NO_2 & TKN sample concentrations.

b. NR = Sample load is lower than target load; no reduction required.

Table H-2 Determination of Estimated Overall Required Nutrient Reduction for West Harpeth River at WHARP017.7WI

Sample Date	Flow	PDFE (Approx.)	Total Nitrogen				Total Phosphorus			
			Sample Concen. [a]	Sample Load	Target Load	Reqd. Reduction	Sample Concen.	Sample Load	Target Load	Reqd. Reduction
	[cfs]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]
10/10/01	1.82	80.8	0.96	9.42	7.30	22.6	0.394	3.87	0.60	84.5
12/18/01	66.9	11.1	2.69	970.6	263.5	72.9	0.349	125.9	21.71	82.8
1/22/02	42.8	21.1	2.27	524.1	166.2	68.3	0.244	56.34	13.70	75.7
2/26/02	23.4	38.3	1.72	216.7	93.23	57.0	0.210	26.46	7.68	71.0
3/26/02	81.5	8.2	2.21	971.4	320.2	67.0	0.470	206.6	26.39	87.2
4/8/02	36.9	25.0	1.77	352.3	145.9	58.6	0.280	55.73	12.03	78.4
5/6/02	47.8	18.4	1.52	391.9	186.5	52.4	0.340	87.67	15.37	82.5
6/25/02	2.10	79.8	1.38	15.62	8.11	48.1	0.579	6.56	0.67	89.8
			Geometric Mean			**53.1**	**Geometric Mean**			**81.3**

Notes: a. Value shown is the calculated sum of NO_3+NO_2 & TKN sample concentrations.

b. NR = Sample load is lower than target load; no reduction required.

Table H-3 Determination of Estimated Overall Required Nutrient Reduction for Little Harpeth River at LHARP001.0WI

Sample Date	Flow	PDFE (Approx.)	Total Nitrogen				Total Phosphorus			
			Sample Concen. [a]	Sample Load	Target Load	Reqd. Reduction	Sample Concen.	Sample Load	Target Load	Reqd. Reduction
	[cfs]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]
10/18/01	14.9	61.2	1.76	140.9	58.17	58.7	0.367	29.38	4.79	83.7
11/20/01	1.33	91.6	0.27	1.94	5.22	NR [b]	0.250	1.79	0.43	76.0
12/13/01	218.9	5.5	0.54	637.3	855.4	NR [b]	0.353	416.6	70.50	83.1
1/23/02	160	9.2	1.26	1,087	624.5	42.5	0.848	731.5	51.47	93.0
2/28/02	29.3	49.8	1.10	173.8	111.2	36.0	0.180	28.43	9.17	67.8
4/11/02	41.3	42.1	0.82	182.5	162.5	10.9	0.180	40.06	13.40	66.6
5/15/02	94.4	19.876.2	1.33	676.6	367.8	45.6	0.260	132.3	30.32	77.1
6/4/02	5.50		1.13	33.51	21.39	36.2	0.320	9.49	1.76	81.4
			Geometric Mean ®			**34.3**	**Geometric Mean ®**			**78.1**

Notes: a. Value shown is the calculated sum of NO_3+NO_2 & TKN sample concentrations.

b. NR = Sample load is lower than target load; no reduction required.

Table H-4 Determination of Estimated Overall Required Nutrient Reduction for Arkansas Creek at ARKAN000.1WI

Sample Date	Flow	PDFE (Approx.)	Total Nitrogen				Total Phosphorus			
			Sample Concen. a	Sample Load	Target Load	Reqd. Reduction	Sample Concen.	Sample Load	Target Load	Reqd. Reduction
	[cfs]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]	[mg/l]	[lbs/day]	[lbs/day]	[%]
10/10/01	1.82	93.0	0.08	0.78	3.07	NR [b]	0.068	0.67	0.18	73.4
12/18/01	6.95	42.3	0.28	10.49	11.53	NR [b]	0.050	1.87	0.67	64.2
1/22/02	6.86	42.3	0.16	5.92	11.53	NR [b]	0.033	1.22	0.67	45.1
2/26/02	8.19	36.2	0.15	6.62	13.58	NR [b]	0.010	0.44	0.79	NR [b]
3/26/02	20.3	9.6	0.76	83.34	34.07	59.1	0.05	5.48	1.98	63.9
4/5/02	7.47	39.2	0.09	3.62	12.55	NR [b]	0.002	0.08	0.73	NR [b]
5/6/02	9.14	32.1	0.25	12.17	15.37	NR [b]	0.002	0.10	0.89	NR [b]
			Geometric Mean ®			**59.1**	**Geometric Mean ®**			**60.7**

Notes: a. Value shown is the calculated sum of NO_3+NO_2 & TKN sample concentrations.

b. NR = Sample load is lower than target load; no reduction required.

APPENDIX I

Development of Nutrient WLAs & LAs

Determination of Waste Load Allocations for WWTFs

WWTFs in selected impaired subwatersheds are assigned individual facility WLAs, expressed as semiannual loads, for total nitrogen and total phosphorus. WLAs are based on the design flows (ref.: Table 8) and existing nutrient discharge concentrations from these facilities. In the absence of effluent monitoring data, and in consideration of the information contained in *Technical Guidance Manual For Developing Total Maximum Daily Loads, Book 2: Streams And Rivers, Part 1: Biochemical Oxygen Demand/Dissolved Oxygen And Nutrients/Eutrophication* (USEPA, 1997a), facility nutrient loading was estimated using the following concentrations :

Time Period	T. Nitrogen	T. Phosphorus
5/1 – 10/31	10 mg/l	5 mg/l
11/1 – 4/30	15 mg/l	7.5 mg/l

Semiannual total nitrogen loading for the Eagleville School (TN0057789) can be calculated for the summer months (5/1 – 10/31):

$[TN]_{Summer}$ = (0.018 MGD) (10 mg/l) (8.34) (30 days)

$[TN]_{Summer}$ = 45.0 lbs/month

where: 0.018 MGD = facility design flow

8.34 = unit conversion factor

Semiannual total nitrogen loading for the winter months (11/1 – 4/30):

$[TN]_{Winter}$ = (0.018 MGD) (15 mg/l) (8.34) (30 days)

$[TN]_{Winter}$ = 67.6 lbs/month

Semiannual loading for total phosphorus is calculated in a similar manner:

$[TP]_{Summer}$ = (0.018 MGD) (8.34) (5 mg/l)(30 days) = 22.5 lbs/month

$[TP]_{Winter}$ = (0.018 MGD) (8.34) (7.5 mg/l)(30 days) = 33.8 lbs/month

WLAs for other WWTFs located in selected impaired subwatersheds are calculated using the same procedure.

Determination of Waste Load Allocations for CAFOs

CAFOs are not authorized to discharge process wastewater from a liquid waste handling system except during a catastrophic or chronic rainfall event. Any discharges made under these circumstances, or as a result of a system upset or bypass, are not to cause an exceedance of Tennessee water quality standards. Therefore, a WLA of zero has been assigned to this class of facilities.

Determination of Waste Load Allocations for Municipal Separate Storm Sewer Systems & Load Allocations for Nonpoint Sources

A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

where (ΣWLAs) includes the contributions from all WWTFs, CAFOs, and MS4s

Expanding the terms:

$$TMDL = \Sigma(WLA_{WWTF}) + Load_{MS4} + (\Sigma WLA)_{CAFO} + Load_{NPS} + MOS$$

where: TMDL = [lbs/month]

WLA_{WWTF} = Sum of WLAs for all WWTFs [lbs/month]

WLA_{CAFO} = Sum of WLAs for all CAFOs [lbs/month]

$Load_{MS4}$ = Semiannual average nutrient load from all MS4 discharges [lbs/month]

$= \Sigma\{(WLA_{MS4})\ (A_{MS4})\}$

$Load_{NPS}$ = Semiannual average nutrient load from all nonpoint sources [lbs/month]

$= \Sigma\{(LA_{NPS})\ (A_{NPS})\}$

MOS = Explicit Margin of Safety [lbs/month]

Solving for ($Load_{MS4} + Load_{NPS}$):

$$(\text{Load}_{MS4} + \text{Load}_{NPS}) = \text{TMDL} - \Sigma(\text{WLA}_{WWTF}) - \Sigma(\text{WLA}_{CAFO}) - \text{MOS}$$

If the $(WLA)_{MS4}$ & $(LA)_{NPS}$ terms are expressed on a unit area basis (lbs/ac/yr):

$$\Sigma\{(\text{WLA}_{MS4})\,(A_{MS4})\} + \Sigma\{(\text{WLA}_{NPS})\,(A_{NPS})\} = \text{TMDL} - \Sigma(\text{WLA}_{WWTF}) - \Sigma(\text{WLA}_{CAFO}) - \text{MOS}$$

where: A_{MS4} = Drainage area of MS4 [acres]

A_{NPS} = Drainage area of nonpoint source [acres]

If $(WLA_{MS4}) = (LA_{NPS})$, and noting that $(\Sigma A_{MS4}) + (\Sigma A_{NPS}) \approx (A_{subw})$, then the left side of the above equation can be rewritten as:

$$\begin{aligned}(\text{WLA}_{MS4})\,(\Sigma A_{MS4}) + (\text{LA}_{NPS})\,(\Sigma A_{NPS}) &= (\text{LA}_{NPS})\,\{(\Sigma A_{MS4}) + (\Sigma A_{NPS})\}\\ &= (\text{LA}_{NPS})\,(A_{subw})\end{aligned}$$

therefore:

$$(\text{LA}_{NPS})\,(A_{subw}) = \text{TMDL} - \Sigma(\text{WLA}_{STP}) - \Sigma(\text{WLA}_{CAFO}) - \text{MOS}$$

Solving for (LA_{NPS}):

$$\text{LA}_{NPS} = \frac{\text{TMDL} - (\Sigma\text{WLA}_{STP}) - (\Sigma\text{WLA}_{CAFO}) - \text{MOS}}{(A_{subw})}$$

The calculation for total nitrogen in Subwatershed 051302040105 during the summer months is shown as an example. Calculations for the winter months, total phosphorus, and other subwatersheds are similar.

Total Nitrogen in Subwatershed 051302040104

$$LA_{NPS} = \frac{TMDL - (\Sigma WLA_{STP}) - (\Sigma WLA_{CAFO}) - MOS}{(A_{subw})}$$

Using an explicit MOS of 5% of the TMDL:

$$LA_{NPS} = \frac{TMDL - (\Sigma WLA_{STP}) - (\Sigma WLA_{CAFO}) - \{(0.05)\ (TMDL)\}}{(A_{subw})}$$

$$LA_{NPS} = \frac{\{(0.95)\ (TMDL)\} - (\Sigma WLA_{STP}) - (\Sigma WLA_{CAFO})}{(A_{subw})}$$

Substituting the appropriate values from Tables 15, 17, & F-1 and noting that $\Sigma WLA_{CAFO} = 0$:

$$LA_{NPS} = \frac{\{(0.95)\ (5865\ \text{lbs/month})\} - \{(25.0\ \text{lbs/month}) + (75.1\ \text{lbs/month})\} - (0)}{(33{,}320\ \text{ac})}$$

therefore:

$$LA_{NPS} = WLA_{MS4} = 0.164\ \text{lbs/ac/month}$$

Semiannual nutrient WLAs for WWTFs, MS4s, CAFOs, and LAs for nonpoint sources are summarized in Table I-1 for total nitrogen and Table I-2 for total phosphorus.